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Sustainability and Climate Action at UT Austin: University Lands Research Project and a Potential Timeline for Progress

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Sustainability and Climate Action at UT Austin: University Lands Research Project and a Potential Timeline for Progress

by

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Abstract

Sustainability and Climate Action at UT Austin: University Lands Research Project and a Potential Timeline for Progress

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The University of Texas at Austin, 2018

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I am a Graduate Research Assistant for the Center for Sustainable Development working on the University Lands project under the Green-Fee, a student fee-funded source of money for special sustainability-oriented projects. I share the role of project lead with Mark Reid, a Master's candidate in Energy and Earth Resources in the Jackson School of Geosciences. We have been researching and organizing our ideas since September of 2017 under the guidance of our faculty advisers, Richard Chuchla, Robert Paterson, and Jake Wegmann and our boss Sarah Wu. The goal of this project is to identify economically viable and beneficial actions for offsetting, sequestering, and reducing greenhouse gas emissions that are compatible with current practices on University Lands, which are the surface and mineral interests in West Texas benefiting the Permanent University Fund of the University of Texas System and the Texas A&M System. Last year, around $600 million came from the oil and gas fund, with almost half going directly to the University of Texas at Austin (Satija and Watkins, 2017). Thus, the fossil fuel industry's success is largely credited for many of the opportunities and successes at UT Austin. However, as a public institution in a time where concerns about

emissions and climate change are growing, University Lands is beginning to include renewable energy as a contributor to that funding.

This report investigates sustainability and environmental and climate action at UT Austin and compares the experiences with two peer universities, Boston University and the University of Virginia. It draws upon successes and challenges at the universities to apply lessons to UT Austin. I then explain my Green Fee-funded research project and its progress so far, concentrating on solar energy and wind energy in particular. This report explores the potential for a fossil fuel-oriented university to use its own lands for fossil fuel mitigation. It asks how this University Lands Green Fee-funded research project and other initiatives at UT Austin compare to other universities' sustainability and climate action initiatives. The report questions: "Can UT Austin use what we find to identify ideas to reduce and offset emissions from University Lands over decades to eventually end fossil fuel use altogether?" In addition, "how does producing renewable energy on these lands fit into reducing fossil fuel use?" Lastly, "how will the research project be used and built upon by UT Austin in the years to come?" The report finds that UT could benefit from more transparent decision-making and should use its ties to energy production as an advantage to become a university leader in sustainability. Additionally, UT would benefit in further connecting research to action. This study shows that wind energy production in the West Texas counties is already cost-effective and that solar has a lot of room to grow, with some questions remaining in reaction to federal policies. A carbon tax or carbon credit scheme in the future would make renewable energy more desirable and profitable. UT Austin researchers in the years to come should build upon our research about renewable energy, methane controls, and other methods and identify specific projects that could reduce emissions and increase profits on University Lands.

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Chapter 1:
Introduction

The University Lands project with the Center for Sustainable Development of the University of Texas at Austin School of Architecture is Green Fee-funded, which means it was selected by a committee in charge of allocating money from a revolving fund to sustainability-related projects formed by the University of Texas at Austin faculty, staff, or students (The University of Texas at Austin Sustainability [UT Austin Sustainability], n.d.b). The fund is sustained by student fees of $5 per semester (UT Austin Sustainability, n.d.b). Green Fee projects have included greenhouse creation, reducing waste from football games, and revitalization of Waller Creek in Austin (UT Austin Sustainability, n.d.b). Green Fee was created in 2011 after Rep. Elliott Naishtat (D-Austin) supported the bill in 2009, allowing the Green Fee for five years once it passed the student ballot vote (Dearman, 2015). It was at risk of expiring in 2016 but was renewed with some conditions (Dearman, 2015).

This research project is relevant now more than ever. Climate change has become more of a broad-reaching threat internationally, and the federal government largely ignores the issue, backing out of the Clean Power Plan and the Paris climate deal and reducing the role of the Environmental Protection Agency. Texas faces impacts from these changes, including sea level rise, intensified storm surges, heat waves, more variable and extreme precipitation events interspersed with droughts, and increased wildfire risks (Despart, 2017; Hayhoe, 2014).

THE UNIVERSITY LANDS AND THE REVENUE THEY GENERATE FOR UT AUSTIN

The University Lands are 2 million acres of surface and mineral property owned by the UT and Texas A&M system in 19 counties in West Texas with thousands of producing oil and gas wells (see Figures 1.1, 1.2, and 1.3) (University Lands, 2017b). The largest lease sale yet, 43,724 acres, occurred in the fall of 2017, producing $118 million in total revenue (University Lands, 2017b). The average lease price was $2,700 per acre (University Lands, 2017b). Hundreds of additional wells will be drilled in the next few years (University Lands, 2017b).

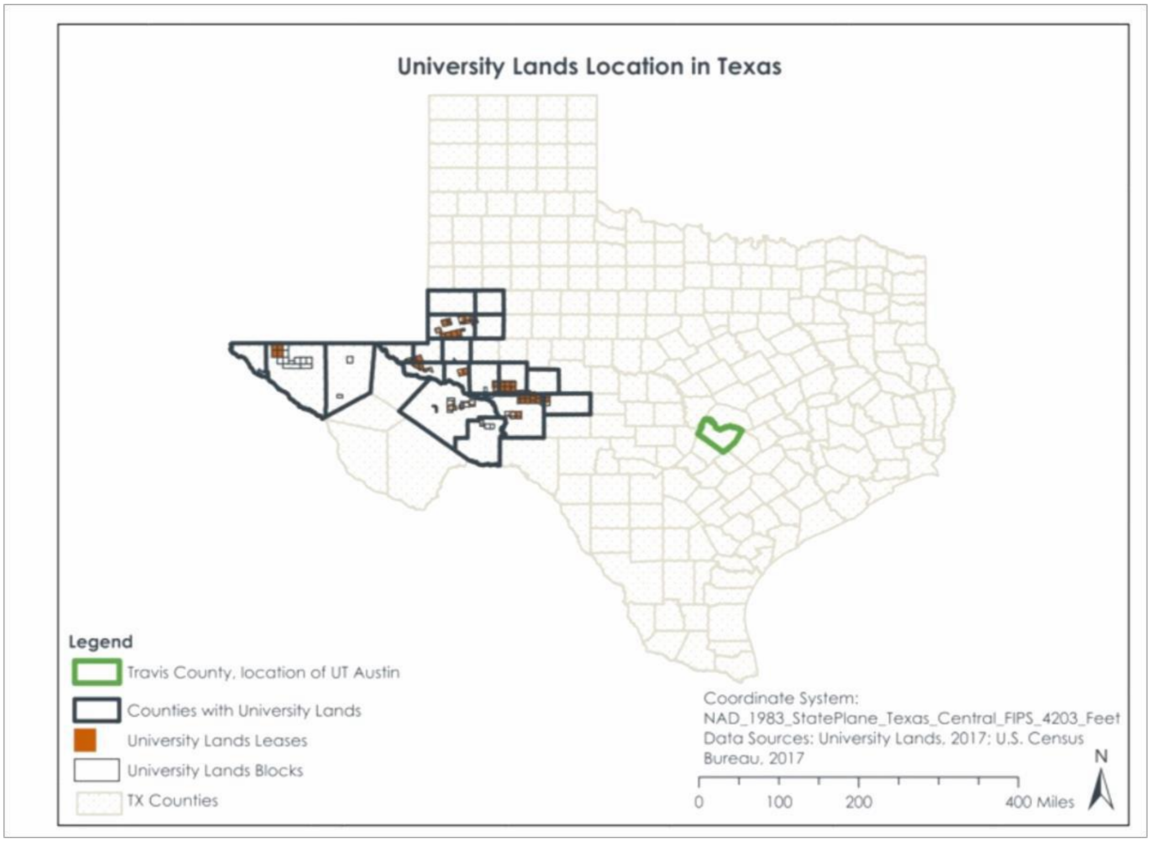


Figure 1.1 (Veazey) Location of University Lands.

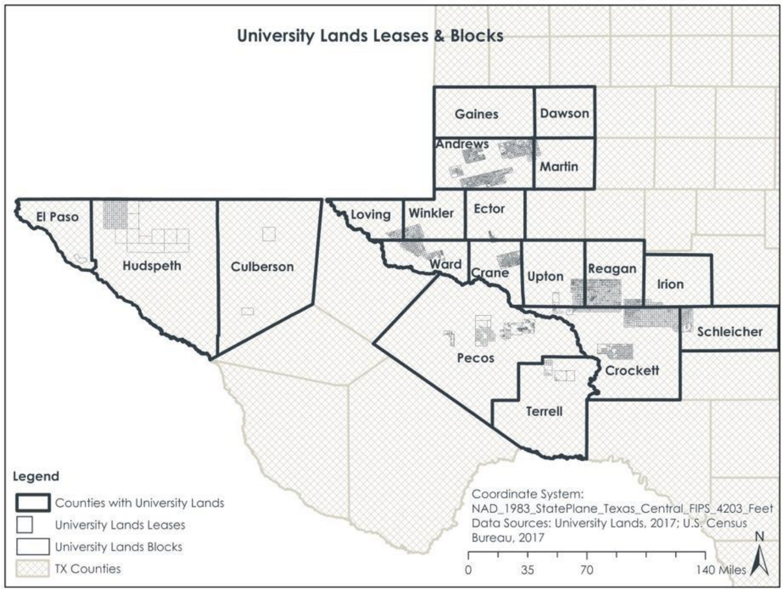


Figure 1.2 (Veazey) Acreage divided into leases and blocks across 19 counties.

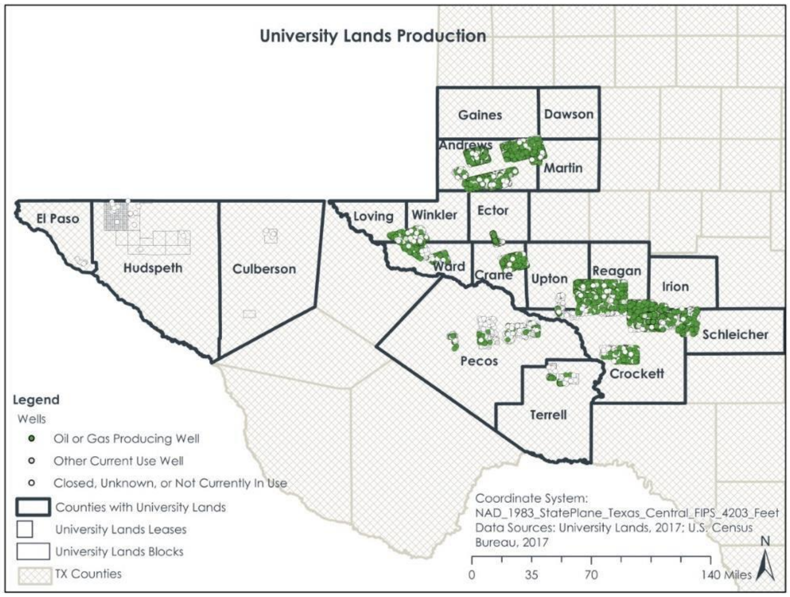


Figure 1.3 (Veazey) Wells by production status.

The profits from University Lands oil and gas leases contribute to the Permanent University Fund (PUF) which is used for the Available University Fund (AUF), which forms part of the endowment. The University Lands were dedicated to all UT System and Texas A & M (TAMU) System schools in 1876 by the Texas Constitution (The University of Texas System, n.d.a; University Lands, 2017b). The PUF is the largest endowment of public higher education institutions in the country, but because it is spread among so many institutions, UT Austin itself does not have the biggest (The University of Texas System, 2017 p. 1). "An endowment is a permanent investment in the future of the University. Endowed funds are invested, rather than used as cash for immediate needs. A portion of the earnings from an endowment is distributed to the University. The remainder is added back into the principal, ensuring steady growth of the endowment" (UTIMCO, 2012a). The endowment is managed by UTIMCO, The University of Texas/Texas A&M Investment Management Company, which

> is governed by nine directors, two appointed by the Texas A&M Board of Regents and seven appointed by the UT Board, including three regents. One appointee of the Texas A&M System and three of the UT System must have substantial investment experience. UT System appointees may include the chancellor. The UT Board retains the ultimate fiduciary responsibility for the PUF, and UTIMCO services are governed by UT Board investment policies, including asset allocations. (The University of Texas System, 2017a p. 1)

UTIMCO has managed the PUF profit and investments and all UT and TAMU system investments since 1996; it is considered a nonprofit under the UT System Board of Regents (The University of Texas System, n.d.a; UTIMCO, 2012a).

The Available University Fund consists of surface income (grazing, vineyards, wind, hunting, and pipeline easements) and mineral income, which includes oil and gas production (The University of Texas System, n.d.a). AUF is used to pay back bonds taken by UT System and TAMU system institutions (McRaven, 2016). "The Constitution allows the UT System to issue bonds guaranteed by the PUF in an amount equal to 20 percent" of the value of PUF investments (McRaven, 2016). The PUF is substantial in size, allowing creditors to trust the bonds and enabling UTIMCO to borrow money at very low interest rates (McRaven, 2016). Two thirds of AUF goes to the UT system and one third goes to Texas A&M (The University of Texas System, n.d.a). The UT System Regents give at least 45 percent of UT system AUF share to UT Austin, unless there are bond debt service needs; 3 percent more went last year for the construction of the new Dell Medical School (Kelly, 2017). The portion (of the UT share going to Austin?) has been 48 to 74 percent for the past 20 years (The University of Texas System, 2017b). UT can use funds for maintenance and support of UT Austin and UT System Administration and for PUF bond and interest payments (The University of Texas System, n.d.a). Because of the Texas Constitution, other institutions in UT System cannot use the funds (The University of Texas System, n.d.a). They cannot be used for athletics or anything operational (The University of Texas System, 2017a).

The PUF is very impactful; "From 2004 to 2013 alone, PUF appropriations funded nearly $1.5 billion worth of projects—everything from a UT Permian Basin Kinesiology Building to a research park complex at UT Health in Houston" (The University of Texas System, n.d.a). AUF simultaneously gets praise for keeping the University affordable and criticism for not doing enough. "On December 31, 2017 the market value and book value of the PUF was $21.0 billion and $17.1 billion, respectively, exclusive of land acreage"

(UTIMCO, 2017). Just some of that goes to the AUF; in 2016 it was $773 million (McRaven, 2016). It makes up about 9 percent of UT's budget (Roush, 2017).

PRAISE AND CRITICISM FOR THE USE OF REVENUES FROM UNIVERSITY LANDS

The PUF is praised for helping maintain low tuition rates. Tuition at UT Austin increased for the 2016-2017 academic year by $152 a semester for in-state undergraduates for the first time since 2011 (Fenves, 2016). Forty percent of full-time undergraduate students receive some type of need-based financial aid, at an average of average $9,587 (U.S. News and World Report, 2018b). In 2017, UT Austin was recognized among just five universities (with the University of California at Berkeley, University of Richmond, Vassar College, and Franklin & Marshall College) by the American Talent Initiative for increasing opportunities for budget constrained students (Williams, 2017). The study shows the "share of institutional aid budget allocated to need-based aid" increased from just over 50 percent from 2007 to 2008 to 96 percent from 2013 to 2014, although the percent of students receiving need-based aid went down in that time (Kurzweil and Brown, 2017, p. 23-24). UT Austin is less expensive than peer universities such as Penn State, the University of Michigan, the University of Minnesota, and the University of Illinois (The University of Texas at Austin, 2018)

The entire Permanent University Fund system has been criticized as well. An article with the title "UT system oil money is a gusher for its administration — and a trickle for students" said "The money that filters down to them in the form of financial aid amounts to a trickle of roughly $40 million. That includes about $3 million for UT-Austin's 40,000 undergraduates, and approximately $35 million for its graduate students" (Satija and Watkins, 2017). The writers argued there has been controversial use of the AUF. This includes "$100 million devoted to an in-house educational technology startup that has struggled to meet its goals" (Satija and Watkins, 2017). This is The Institute for Transformational Learning, which is now closed (The University of Texas System, 2018). The statement on the website says "The University of Texas System is closing the Institute for Transformational Learning, effective January 31, 2018. The UT System is in the process of moving appropriate initiatives to participating University of Texas institutions. We would like to express gratitude to our many partners over the past few years" (The University of Texas System, 2018). Another criticism of UT Austin spending includes hundreds of millions of dollars on a skyscraper in downtown Austin as an office space for UT system staff (Satija and Watkins, 2017). Bill McRaven, the UT Austin Chancellor since 2015 who is stepping down in late May 2018, replied that "with an efficient new building as an economical way to decrease annual maintenance and operating costs by millions of dollars" it could produce about $200 million net (Haurwitz, 2018; McRaven and Adler, 2017).

The critics continue: "The system preserves the fund for the long-term by spending only a small fraction of it every year. Still, that amounts to $603 million for the UT System alone in 2017 — more than the Legislature spends on its main financial aid program for low-income students across the state" adding that "whatever the system doesn't use goes to UT-Austin, which is free to spend it on whatever it wants" (Satija and Watkins, 2017). However, the last statement is not true. UT can use funds for maintenance and support of UT Austin and the UT System Administration or for PUF payments, whereas operational expenses and certain capital expenses, like those related to athletics, are off-limits (The University of Texas System, 2017a; The University of Texas System, n.d.a).

Using University Lands More Sustainably

Critics question whether universities should make risky innovative investments and ask whether keeping tuition fairly low is a priority. This ties to my broader research question of how to introduce more sustainable uses of University Lands while being realistic about the current uses of the land and appreciating the economic benefits UT receives from that. For some it does not sit right that the UT System owns oil and gas producing lands yet are not doing enough to limit emissions. Others appreciate the research and academic opportunities and accessibility offered by a university with a large endowment. Others want more investment in financial aid. How much can or should a university respond to student and faculty opinions on investment and spending? What are the impacts and repercussions?

Chapter 2: Sustainability & Climate Action at UT Austin

UT Austin has been making strides in sustainability and climate action in recent years. This includes in research and education and in campus functioning. In academics, 2016 saw the creation of Sustainability Studies as a Bachelor's in Arts in the Liberal Arts College and the Department of Geography and the Environment, a cross-disciplinary degree in content (Griess, 2016). Innovative research has been vital in aiding the university in being more sustainable and reducing its impact. One example is the Carbon Roadshow. The Carbon Roadshow was a Green Fee-funded project by the Center for Sustainable Development, the Office of Sustainability, and the Energy & Water Conservation Program at UT that was completed from 2015 to 2017 (Texas Architecture, 2017). It accounts for the carbon footprint of the School of Architecture and provides a way to find a carbon footprint for each department in all schools at UT Austin. The project covers Scope 1 emissions (direct, generated onsite at the natural gas plant),[1] Scope 2 emissions (those that are indirect like purchased electricity from Austin Energy), and Scope 3 indirect emissions (such as supply chain, commuting, and waste-related emissions) (Texas Architecture, 2017). Considering everything, the University of Texas was found to emit less than Ohio State but more than Pennsylvania State, Texas A&M, and Arizona State among peer institutions (Texas Architecture, 2017). Nonetheless, the campus is on track for its goal of decreasing energy use by 20 percent below 2009 levels by 2020 (Texas Architecture, 2017).

[1] UT Austin has had an on-site natural gas plant since 1928 when the university chose to become independent of Austin Energy, which had plants powered by coal, to try to create more reliable and efficient energy for the campus (Malewitz, 2016).

On the other hand, there is a lot of room to grow in sustainability research related to energy at UT. Research funding from government agencies, energy companies, NGOs, and private donors going through UT for energy is largely focused on fossil fuels (Energy Institute, 2017c). Research on carbon management and renewable energy has not been funded as much as it used to over the last few years (Energy Institute, 2017c). The University Lands project has the potential to be an important contributor to an uptick in this type of research, as it could influence other researchers to later build on its goals and develop some of the specific proposals within it.

Some of the most important and most visible recent work and programs at the University of Texas at Austin includes the Sustainability Master Plan, the Campus Master Plan, the work at the Office of Sustainability and the Campus Environmental Center, and the campaign to reduce methane emissions on University Lands. This chapter provides a summary of much of the work in sustainability, environmental protection, and climate action at UT in the present and recent past. UT Austin is the flagship campus of the UT System, so there is potential for the vision and goals of UT Austin to reflect the future actions of the system as a whole.

THE SUSTAINABILITY MASTER PLAN

The University of Texas at Austin's (2016) "Sustainability Master Plan" was published in the fall of 2016. It outlines sustainability successes and proposals in the campus's actions, education, and research functions through the year 2030. The University of Texas at Austin has had some sort of campus sustainability policy since 2008 (The University of Texas at Austin, 2016). UT aims for the plan "to provide overall direction and goals for how sustainability is pursued in service to the mission and purpose of the institution" (The University of Texas at Austin, 2016, p. 9). This plan opens with a statement from President Gregory Fenves including: "As the state, nation and world focus on achieving sustainability, The University of Texas at Austin must consider how to best use natural and financial resources, work together toward a common end and adapt our educational mission to the emerging needs of our students and society" (The University of Texas at Austin, 2016, p. 4). His goals are partly informed by the President's Sustainability Steering Committee, and he says that money matters, stating "we are mindful that taxpayer and tuition dollars must be used wisely. The strategies in this plan will be assessed on their return on investment" (The University of Texas at Austin, 2016, p. 4). Among the values of the plan, are "innovation-Pursuing better resolutions to the next challenge," and "responsibility – To serve as a catalyst for positive change in Texas and beyond" and "Resiliency – Planning for the opportunities hidden in the uncertainties facing future generations" (The University of Texas at Austin, 2016, p. 11). I view these as applicable to my University Lands project that aims to limit greenhouse gas emissions in creative and open-minded yet context-specific ways and to consider how UT can approach its energy production and land use looking forward into the years ahead.

Creation of the "Sustainability Master Plan" included efforts by the Sustainability Master Plan Working Group, outreach, and many drafts (The University of Texas at Austin, 2016). The stakeholders decided on general directions to take first and followed with specific strategies (The University of Texas at Austin, 2016, p. 9). The leaders report on progress every two years and update the document every five years (The University of Texas at Austin, 2016, p. 18). They hope UT Austin will become "recognized as a leader in sustainability among public research universities" (The University of Texas at Austin, 2016, p. 19).

The document is largely about on-campus initiatives, emphasizing choices, actions, and awareness of students, faculty, and staff on topics such as food, transportation, courses, zero waste athletics, and first year orientation (The University of Texas at Austin, 2016). However, the plan also covers green buildings, green purchasing, materials, and water conservation and other behind-the scenes facilities and maintenance issues (The University of Texas at Austin, 2016). Among the most notable green amenities at UT Austin are its natural gas-powered power plant, said to be the most efficient power plant in the country, built in 1928 as a way to make UT independent of the City of Austin's coal-powered electricity, and the Green Fee, a revolving fund supplied by student tuition fees that funds sustainability-oriented projects each semester as selected by the Green Fee Committee, which has a student majority and also includes staff of the Office of Sustainability (Malewitz, 2016; The University of Texas at Austin, 2016).

A few sections of the "Sustainability Master Plan" touch on energy in the realms of courses, research, conservation and consumption, and renewables (The University of Texas at Austin, 2016). In terms of research, the report cites an Energy Institute number of $70 million annually brought into or moving within UT Austin for research associated with energy (The University of Texas at Austin, 2016, p. 44). It states:

The university has a long tradition of research in conventional energy fields and a growing nexus of research in alternative energy and energy storage fields. A recent Office of Sustainability study of active awards in 2013 in the Office of Sponsored Projects found 12% were focused on sustainability issues, including non-engineering and geoscience fields such as environmental, natural and social sciences. We will continue leadership in our historical areas of strength and build our efforts in emerging sustainability fields. (p. 44)

My University Lands project is one that is cross-disciplinary between a social science, Community and Regional Planning, and a hard science, Energy and Earth Resources. The University of Texas at Austin arguably offers a substantial number of sustainability-oriented courses. The “Sustainability Master Plan’s” Civil Discourse section reads:

> Strategies: Develop seminar series on financial diversification and divestment; Develop seminar series on environmental impact of fracking on UT lands; Develop process for student-driven seminar series topics. Outcomes: Launch a new scholarly series by 2018. (The University of Texas at Austin, 2016, p. 46)

It is unclear what is meant by “divestment” here; implying removing investments from fossil fuels, as divestment is often but not exclusively framed, would be controversial. Following up with these strategies, the only courses on fracking (hydraulic fracturing) I found from the Fall 2017 semester and the Spring 2018 semester were a Petroleum and Geosystems Engineering course on the technicalities of fracking and a law course “Fracking & More: Environmental Issues” that was canceled, but The University of Texas at Austin Sustainability promises a sustainability course database is being built as of the time of writing in spring 2018 (Office of the Registrar, 2018; The University of Texas at Austin Sustainability, n.d.a). The growth of course offerings in sustainability and environmental topics could help prepare future researchers to build upon the University Lands project and similar projects.

Beyond teaching and research, the plan explores how energy enables the university to function day-to-day. The campus power plant provides nearly all of UT Austin’s power (The University of Texas at Austin, 2016, p. 49). The conventional pattern would be to expand or build more power plants as the university grows, but instead, UT Austin’s system uses natural gas turbines to capture energy that would be wasted otherwise for heating, cooling, and water on campus (Malewitz, 2016). The system is a district energy system, which means cooling or heating water to be piped underground to buildings from a centralized power source (Malewitz, 2016). UT regularly updates the power plant equipment and generates energy at the least expensive times of day; the ability to store cooled water is an important part of these efficiency successes (Malewitz, 2016). These methods lead to energy savings, emissions reductions, and cost savings. UT Austin uses approximately 87 percent of the energy in the natural gas typically, which is much greater than the portion used at conventional facilities (Malewitz, 2016). According to a presentation at the School of Architecture by Jim Walker (2017), UT Austin's Director of Sustainability, the industry standard is about 30 percent. Juan Ontiveros, the associate vice president for Utilities, Energy and Facilities Management at UT, estimated in 2016 there were $90 million in savings in fuel costs in the preceding 15 years (Malewitz, 2016). The university has been making impressive strides on efficiency, as fuel consumption was constant between 2001 and 2016, even while the campus building space total doubled. While the university achieved this milestone, its 2016 carbon emissions remained equal to 1977 levels (The University of Texas at Austin, 2016, p. 49). The plan states:

> In 2011, the Natural Resource Conservation Plan set a goal of reducing energy consumption at the building level by 20% by the year 2020 using 2009 as the base year. As of FY2014, 16.5% energy reduction has been achieved via technical efforts and campus engagement. (p. 49)

As of January 2018, there were no additional updates to be found on this number. The plan aimed to ratify operational and purchasing policies for conserving energy by 2017; following up on this, the Green Purchasing Policy of 2012 notes "[while] the initial policy is broad and general, the Office of Purchasing and Office of Sustainability are collaborating on more detailed recommendations that are realistic and substantive" (The University of Texas at Austin, 2016, p. 50; The University of Texas at Austin Sustainability, n.d.d). There is very little about renewable energy in the plan. It makes sense, as the power plant enables the university to be independent of the city's electrical utility in an efficient and safe manner. Nonetheless, the plan aimed to ratify a "solar system campus standard by 2018," but it is unknown if this is still to occur or already happened internally (The University of Texas at Austin, 2016, p. 50).

The report calls for "[identifying] funds to support graduate research and employment in sustainability" (The University of Texas at Austin, 2016, p. 25). If the Green Fee and other funds continue supporting student-led projects, students could build upon the University Lands project in the next several years, helping match the current practices and need to contribute to the Permanent University Fund with the commitment to have UT Austin act responsibly by limiting greenhouse gas emissions and being future-oriented.

The "Sustainability Master Plan" reported on a poll of student, faculty, and staff opinions and trends. It found that 80 percent of the members of the UT Austin campus community "feel sustainability should be a high priority over the next 15 years" as of 2016 (The University of Texas at Austin, 2016, p. 72). There is no serious divide in this opinion; this includes 79 percent of undergraduates, 82 percent of graduate students, 82 percent of faculty, and 80 percent of staff (The University of Texas at Austin, 2016, p. 72). Energy in sustainability generally and investing in renewable energy have 78 percent support and 74 percent support, respectively, as high priorities (The University of Texas at Austin, 2016, p. 72). With this kind of backing from the majority, actors at UT Austin could team up with the rest of the UT System and other regional entities, such as the Texas Regional Alliance for Campus Sustainability, a "statewide network that embodies inter-campus collaboration and aspires to lead the world into a sustainable future committed to environmental preservation, economic development, and social equity," to plan for the future of the PUF and all things energy at UT (Texas Regional Alliance for Campus Sustainability, n.d.).

THE CAMPUS MASTER PLAN AND THE UT AUSTIN CAMPUS

The "Campus Master Plan" was published three years before the "Sustainability Master Plan" and was frequently mentioned within it. Its purpose is that of a typical Master Plan, to layout a comprehensive set of decisions about the UT Austin campus. One of the four main values of the Campus Master Plan is sustainability, along with connectivity, campus quality, and campus use (The University of Texas at Austin, 2013, p. 1). It is relevant to this study of University Lands and their use because it continues to inform the overall vision of UT Austin.

The plan covers building footprints, water use, materials, transportation options, landscaping, and more (The University of Texas at Austin, 2013). It addresses how the campus is growing in square footage and what can be done to help it grow wisely (The University of Texas at Austin, 2013). UT Austin was in support of a 2014 proposal for a light rail system in Austin (that failed to get the necessary votes in a public referendum) and continues to support the idea (The University of Texas at Austin, 2013, p. 45; Webber, 2018). Supporting lower-emissions mass transit encourages dense urban development and healthier and more environmentally-friendly travel patterns and lifestyles. It reduces the need for parking on campus. The sustainability section of the plan covers reducing emissions and improving accessibility via its "mobility strategy" and making campus sections more walkable; it also covers compact building, conserving water, avoiding heat gain, and retrofitting buildings (The University of Texas at Austin, 2013, p. 65 and 93). The 2008 Campus Sustainability Policy aimed to have all new buildings be LEED (Leadership in Energy and Environmental Design) certified (Utilities and Energy Management, n.d.). Newer buildings are impressive representatives of LEED, like the Dell Transformation Building, which has a 11,000 square foot green roof, with native plants and cacti (Jim Walker, 2017). It will need no irrigation after an introductory period of two to three years (Jim Walker, 2017). At Dell Medical as well, there is a renewed focused on transit, bicycle, and pedestrian access and less focus on private cars than has been typically used (Jim Walker, 2017). The "Sustainability Master Plan" that came later complements the elements that attempt to reduce and cut down on environmental impacts in the "Campus Master Plan."

When it comes to energy, UT Austin is a PEER (Performance Excellence in Electricity Renewal) certified campus and became the first worldwide in 2014 (Utilities and Energy Management, n.d.). This means it achieved the necessary standard of power system performance and electricity delivery (Utilities and Energy Management, n.d.). UT Austin also has the online Energy Portal showing real-time and historical data about water and energy in its buildings (Jim Walker, 2017). In the "Campus Master Plan," energy is one of the seven sustainability themes. Efficiency is the focus with renewables playing a supplementary role, with the aim to "promote the use of energy from renewable sources where appropriate" and "[by] August 31, 2020, 5% of all energy consumed by UT Austin facilities on the Main Campus, approximately 17M KWH, will be generated from renewable sources" (The University of Texas at Austin, 2013, p. 186). Jim Walker (2017) clarified that solar photovoltaics would simply not put a dent in the campus's energy demand. Solar photovoltaic panels are clearly a major investment (around $1.85 per watt Direct Current), use up a lot of rooftop space, and create a design conflict with the UT Austin campus' red tile roof vernacular (Jim Walker, 2017; Fu et al., 2017). The most likely argument for solar panels would be if they are tied to "social benefits" or have a "research connection," according to Jim Walker (2017). UT Austin is already experienced at using natural gas in incredibly efficient ways, so the argument towards on-campus renewables is weak, for now. A larger goal is striving to "reduce energy consumption at the building level by an average of 20% per square foot per degree-day by August 31, 2020 using 2009 as the base year" (The University of Texas at Austin, 2013, p. 186). The plan elaborates that it is not only the electrical systems and the highly technical systems, but that solar orientation, shading and material use to prevent "heat island effect" can help lower energy use (The University of Texas at Austin, 2013, p. 186). For example, the solar panels at Dell have an additional function of shading the parking lot (Jim Walker, 2017). Overall, the Campus Master Plan is an essential counterpart to the Sustainability Master Plan that zooms in on specifically facility-oriented goals.

THE OFFICE OF SUSTAINABILITY

The Office of Sustainability has existed since 2010, and it leads the Green Fee Committee that decides on Green Fee projects each semester and the Campus Environmental Center (CEC), which is the student-led environmental issue organization on campus (The University of Texas at Austin Sustainability, n.d.c). The CEC has programs including BATX, which educates students on bats' ecological roles here in Austin, Green Events to consult student groups on how to run events with smaller footprints, Green Greeks to work with UT's sororities and fraternities, Half-Pint Urban Prairie, to "[repurpose] empty or abandoned space on campus," the Microfarm that uses sustainable and organic farming methods, and Trash to Treasure, which is a series of donation campaigns and sales to stop clothes and other items from being sent to the landfill (Campus Environmental Center, n.d.).

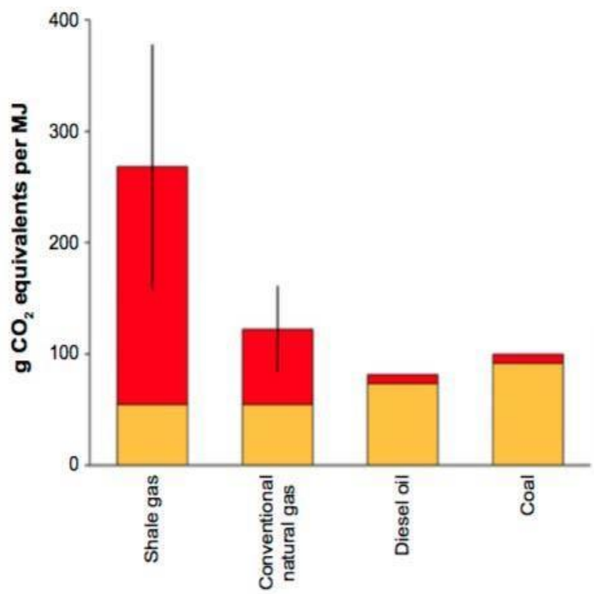
The Office of Sustainability is always innovating and implementing new initiatives, including strategies that address campus functions and programs that give back to the local community. One such program is intended to restore the campus' natural urban wilderness, including planting native trees along Waller Creek (Phillips, 2017). UT Austin is a member of Tree Campus USA, a nationwide program aimed at "[sustaining] healthy community forests” (Arbor Day Foundation, 2017; Phillips, 2017). The university also implemented a program to donate the football stadium’s uneaten catering food, totaling more than 2,500 meals’ worth of food in the fall of 2017 for people in need (Carroll, 2017). Food waste in the United States is a huge problem that is challenging to tackle. While 31 percent of food is wasted according to the EPA (2016) and many laws encourage food donation from restaurants especially, some laws prevent food that has been served from being donated for food safety and bacterial infection prevention, so it is important that universities like UT Austin act as leaders in doing whatever possible to bring awareness to and take action on preventing food waste. The program could take these actions a step further possibly by implementing a program that orders and prepares a better estimate of the amount of food that will be needed at each game, allowing the smaller amounts of extra food to fit in the refrigerators to allow them to be donated. These are just a few of the initiatives currently happening within sustainability at UT Austin showing that the issues reach across academics, facilities, athletics, and more.

METHANE EMISSIONS AND THE UT AUSTIN CAMPAIGN TO REDUCE THEM

UT Austin faculty and staff teamed up with Environment Texas to lead a campaign to reduce methane emissions at oil and gas production on University Lands over the past few years. Our report with the Center for Sustainable Development will illustrate how updating and repairing methane controls is a feasible, affordable solution with a fairly short-term timeline. If University Lands required lease holders to abide by certain standards and technology requirements, they would make a major impact in lowering methane emissions.

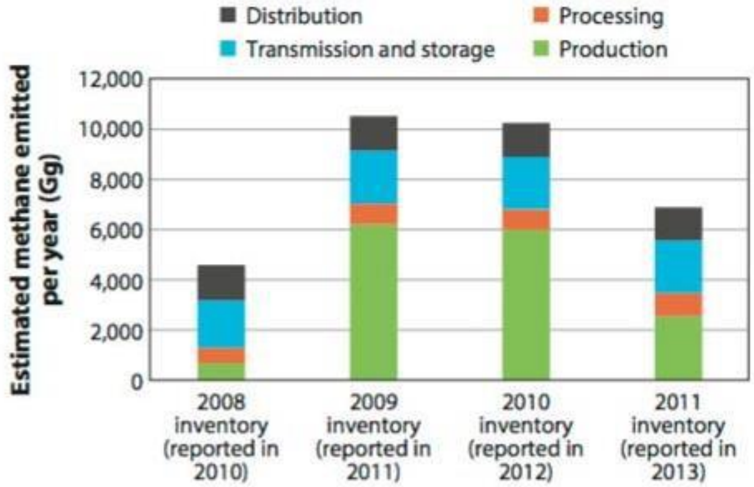
The production of fossil fuels like oil and natural gas creates emissions, methane among them (Environmental Protection Agency [EPA], 2017b). Methane also results from agricultural practices, from natural processes, and from the decaying organic matter in landfills (EPA, 2017c). Behind carbon dioxide, methane is the next largest greenhouse gas emitted in the U.S. (Bluestein et al., 2015).

The impact of methane compared to carbon dioxide (CO2) depends on the GWP, Global Warming Potential, used. Bluestein et al. (2015) uses a GWP of 25 for methane and reports that the United Nations Framework Convention on Climate Change and the EPA do as well. This implies that a pound of methane emitted is equal to 25 pounds of CO2 in the atmosphere over a 100-year timeframe, because methane is better at absorbing heat than carbon dioxide (Bluestein et al., 2015, p. 5; EPA, 2017c). However, the Intergovernmental Panel on Climate Change (IPCC) uses a 28 to 34 GWP (Myhre et al., 2013, p. 714). Howarth (2015) uses a GWP of 86 over a 20-year timeframe. Shown in red in Figure 2.3, below, Howarth (2015) said this “far better accounts for the importance of methane to global warming in the critical next few decades” (p. 51). Howarth (2015) pushes for better policy limiting methane emissions during all steps of shale gas production. If one uses Howarth’s (2015) GWP that suggests methane is more potent than the EPA does, one can argue that the shale gas (hydraulic fracturing) form of natural gas production has led to increased greenhouse gas emissions between 2009 and 2013, despite the fact that carbon dioxide emissions have decreased since natural gas began replacing coal as a common fuel. Hydraulic fracturing (“fracking”) creates more methane emissions than conventional methods, so as fracking becomes more popular, methane emissions have gone up (Allen, 2014). Figure 2.1 shows that shale gas (fracking) creates lower direct plus indirect carbon dioxide emissions than oil and coal (in yellow), but the CO_2 equivalent of methane is much more (in red) (Howarth, 2015, p. 49). Using Howarth’s (2015) assumptions, the methane emissions overall would go down (the green line in Figure 2.3) if shale gas (fracking) emissions were lowered to the level of conventional natural gas emissions. It is expected that 49 percent of natural gas production will be from fracking by 2035; it was already over 30 percent in 2014 (Allen, 2014). These arguments all have credit but are a part of a contentious debate about which GWP to use, and no reasoning discredits the fact that replacing coal with other energy sources results in some broader improvements in public health and lowered carbon dioxide emissions.



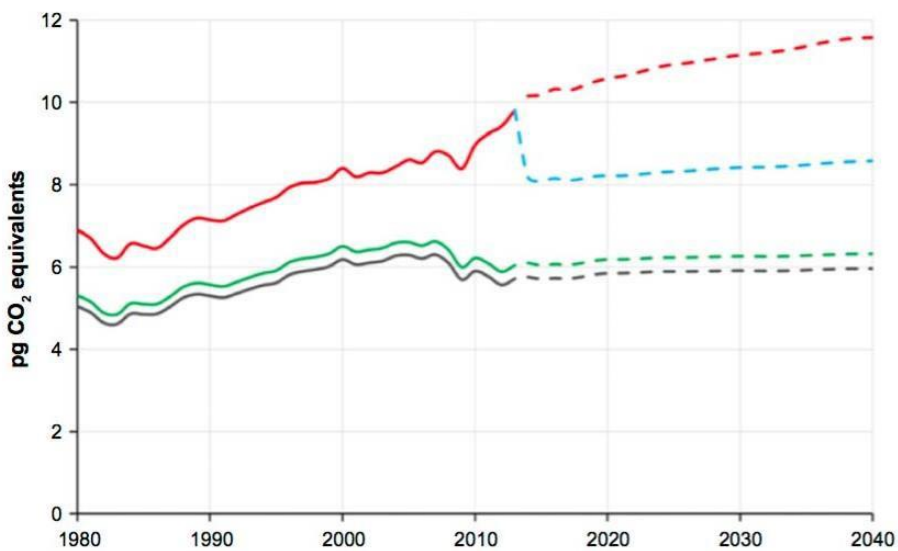
The greenhouse gas footprints of shale gas, conventional natural gas, oil, and coal expressed as g CO_2 equivalents per MJ of heat produced.
Notes: Yellow indicates direct and indirect emissions of carbon dioxide. Red indicates methane emissions expressed as CO_2 equivalents using a global warming potential of 86. Vertical lines for shale gas and conventional natural gas indicate the range of likely methane emissions. Emissions for carbon dioxide for all fuels and for methane from conventional natural gas, oil, and coal are as in Howarth et al.[11] Mean methane emission estimate of shale gas is taken as 12% based on Schneising et al[36] as discussed in the text.

Figure 2.1 (Howarth, 2015, p. 49)
Hydraulic fracturing emits high
amounts of methane.



Estimated methane emissions along the natural gas supply chain, 2008–2011. Emission estimation methods, particularly for production processes, have varied over this period, producing large changes in estimates (32).

Figure 2.2 (Allen, 2014) Estimated methane emissions.



Trends in greenhouse gas emissions from fossil fuel use in the USA from 1980 to 2013 and future trends predicted until 2040 based on historical energy use and energy predictions in the *Annual Energy Outlook 2015.*[1] Shown are: emissions just for carbon dioxide (gray line); emissions for carbon dioxide and for methane using EPA assumptions, which undervalue the importance of methane (green line); emissions for carbon dioxide and methane based on emission factors for conventional natural gas, oil, and coal from Howarth et al,[11] mean methane emission estimates for shale gas of 12% based on Schneising et al[36] as discussed in the text, and a global warming potential for methane of 86 (red line); and future emissions for carbon dioxide and methane based on the same assumptions as for the red line, except assuming that shale gas emissions can be brought down to the level for conventional natural gas (blue line). Historical data are shown by solid lines; dashed lines represent future predictions.
Abbreviation: EPA, Environmental Protection Agency.

Figure 2.3 (Howarth, 2015, p. 50) Methane based on a GWP of 86 shown in red.

Within its campaign to reduce methane emissions from University Lands, UT Austin is focusing on the retrofit pneumatic controllers. In summary, pneumatic controllers:

> use gas pressure to control the operation of mechanical devices, such as valves. The valves, in turn, control process conditions such as levels, temperatures, and pressures. When a pneumatic controller identifies the need to change liquid level, pressure, temperature or flow, it will open or close a control valve in order to return to a desired set point . . . Controllers can deliver this type of service . . . through either continuously venting or intermittent venting of gas. (Allen et al., 2014, p. 634)

With natural gas production, the valves can release methane (see Figure 2.2 and Figure 2.4). A method to reducing methane emissions is to require University Lands' leaseholders to repair or replace devices to prevent most methane venting and leaks and to meet predetermined methane emission limits.

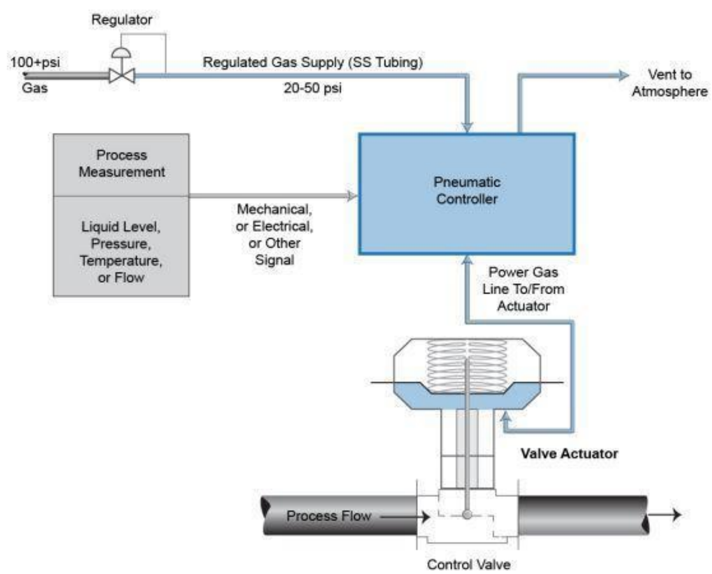


Figure 2.4 (Center for Energy and Environmental Resources, n.d.) A diagram of a pneumatic controller and technology.

According to the EPA (2017b), 10 percent of U.S. greenhouse gases (GHGs) caused by human activity in 2015 were methane and 31 percent of all U.S. methane emissions that year came from natural gas and oil. Similarly, ICF says 29 percent of methane emissions come from natural gas and oil (Bluestein et al., 2015). Notably, about half of the methane emissions from oil and gas systems come from the production process (Bluestein et al., 2015). Natural gas well pad emissions come from leaks, pneumatic devices, compressors, storage tanks, dehydrators, and unloading liquids from wells (Bluestein et al., 2015). Oil well pads also can emit methane (Bluestein et al., 2015). The "leakage rate," which is the proportion of methane emissions out of all natural gas produced yearly, was 1.3 percent in the 2013 U.S. Inventory from the EPA (Bluestein et al., 2015, p. 4). According to a 2011 study, the full lifetime (well-to-consumer) rate was 3.8 percent (with ±2.2% margin of error [MOE]) for a conventional gas well and 5.8 percent (with ±2.2% MOE) for shale gas, due to venting during high-volume hydraulic fracturing flowback period (Howarth, 2015, p. 46). In Allen et al. (2013), a study of 190 natural gas production sites including "150 production sites, 27 well completion flowbacks, 9 well unloadings, and 4 workovers," was described as having some results similar to, some as higher, and some as lower emissions than EPA studies. For example, the study found emissions from intermittent and low bleed pneumatic devices were higher than EPA's estimates (Allen et al., 2013). Only some of these sites were in the Gulf Coast region, which includes Texas (Allen et al., 2013). However, the "[emissions] per pump from the Gulf Coast are statistically significantly different and roughly an order of magnitude higher than from pumps in the Midcontinent. Emissions per controller from the Gulf Coast are highest and are statistically significantly different from controller emissions in the Rocky Mountain and Appalachian regions" (Allen et al., 2013).

The Allen et al. studies (2013; 2014) originally found two numbers for an average of standard cubic feet per hour (scf/h) bleeding from pneumatic controllers of fracking wells: first 10.5 then 4.9. The latter study also found that most pneumatic controllers were performing well and bleeding very low levels of methane (Allen et al., 2014). Sixty-two percent of controllers have very low emissions, less than 0.01 scf/h (Allen et al., 2014, p. 636). Meanwhile, only "20 percent of devices accounted for 96% of whole gas and methane emissions" (Allen et al., 2014, p. 636). The Gulf Coast average for methane emissions was high, however, at 10.61 scf/h (Allen et al., 2014). A more detailed study of 40 controllers with the highest emissions rates revealed many were bleeding continuously or malfunctioning otherwise, so some controllers could probably be repaired instead of replaced (Allen et al., 2014, p. 639). In summary, this small proportion of high-bleed controllers are those that need to be repaired, replaced, and regulated to most successfully reduce methane emissions at drill sites.

The EPA (2017a) reported that in 2015, 162.4 million metric tons of carbon dioxide equivalent of methane were emitted through the lifecycle of natural gas systems, although this is with a decrease of approximately 16 percent since 1990, "largely due to … reduced compressor station emissions (including emissions from compressors and fugitives) … increased use of plastic piping, which has lower emissions than other pipe materials, and station upgrades at metering and regulating (M&R) stations" (p. ES-15). Similarly, methane emissions from petroleum systems declined by about 28 percent during that time, "primarily due to decreases in emissions from associated gas venting and flaring" (EPA, 2017a, ES-15). These decreases occurred while gross natural gas withdrawal in the U.S. increased between 1990 and 2015 (Bluestein et al., 2015). Therefore, there has been some success in using technology to limit emissions, but further regulations or management of lands in Texas could make a large difference.

Some regulations exist and some have been under threat of being reduced recently. The U.S. Code of Federal Regulations Title 40, Part 98, Subpart W, requires facilities emitting 25,000 metric tons or more GHGs to report them from specific sources (Bluestein et al., 2015). EPA has improved the New Source Performance Standards (NSPS) since 2015 (Bluestein et al., 2015). President Trump's EPA aimed to end the proposed regulations on fugitive emissions and pneumatic pumps, but a stay of the NSPS updates by the EPA in Spring 2017 was lifted by the U.S. Court of Appeals for the District of Columbia that July (Passut, 2017). The 2016 NSPS for methane applies to pneumatic controllers, along with pneumatic pumps, equipment leaks, and "completions of hydraulically fractured wells" at both oil and natural gas wells. It also regulates natural gas compressors and processing plants (EPA, 2016e). Recently, attempts have been made to rewrite the rule, so it is unclear what the methane emissions regulations (or lack thereof) federally might be in the coming years (Lefebvre, 2017). Other programs intended to limit greenhouse gases include the EPA Natural Gas STAR Program, used to replace high bleed pneumatic controllers with low bleed versions, ONE Future, and Climate and Clean Air Coalition (CCAC) Oil and Gas Methane Partnership (OGMP) (Bluestein et al., 2015). States and owners of considerable amounts of land like University Lands can take emissions reductions methods into their own hands.

It is worthwhile noting that climate change is not the only threat from leaking and venting oil and gas wells. Emissions controls might be good for public health too if they prevent toxins from being emitted. Data about pollutants for natural gas production and health impacts is somewhat scant but reveals risks. For example, benzene has been detected in some regions (Allen, 2014). Other samples have included "formaldehyde, chloroform, carbon tetrachloride, and other halogenated organics" (Allen, 2014, 71). The Department of Health and Human Services (DHHS) has confirmed benzene causes cancer in humans, especially leukemia, with long-term exposure (Center for Disease Control [CDC], 2013). Other possible suspected effects include bone marrow damage and delayed formation of bones in newborns and low birth weights (CDC, 2013). Formaldehyde can “irritate your eyes, nose, throat, airways, or skin,” particularly for sensitive populations (CDC, 2016). High, continuous levels of formaldehyde exposure (such as that of certain industrial and energy workers) is connected to rare cancers of the nose and throat (CDC, 2016).

Due to a lack of state regulation and the need for federal regulations to be stronger, Environment Texas has helped support a campaign at UT Austin to get University Lands to lower methane emissions since 2015 (Metzger, 2017a). Additional research from Environment Texas addressed broader numbers, such as an “equivalent of 11.7 million metric tons of carbon dioxide” from University Lands over 6 years, which has the effect of “about 2.5 million cars” in emissions (Environment Texas, n.d.). The organization points to other states, such as Colorado and California, to serve as models for Texas; they too have significant oil and gas production and have more stringent methane emissions reduction policies (Environment Texas, n.d.). The methane issue gained recognition partially from infrared videos showing methane leaking at oil and gas wells, storage tanks, and flares (Metzger, 2016). A petition for setting restrictions on University Lands in order to reduce methane emissions circulated around UT Austin, UT Arlington, and UT San Antonio in the fall of 2016 via students’ groups teamed up with Environment Texas, and it gained around 2,800 signatures (Metzger, 2016; Cobler, 2016). In September 2016, UT Austin Student Government passed legislation calling on “UT System Chancellor William McRaven to publicly support cutting University methane emissions in half,” leaving it up to him to in turn influence University Lands (Cobler, 2016). Then, in April 2017, UT System faculty gave a letter signed by over 150 faculty members of UT Arlington, UT Austin, UT Dallas, UT El Paso, UT Health Science Center at Houston, UT Rio Grande

Valley, and UT San Antonio to UT Chancellor Bill McRaven asking for a reduction in methane emissions at University Lands (Metzger, 2017a). It called for a task force to study the issue (Metzger, 2017a). On December 11, 2017, UT Faculty Council voted unanimously for a resolution to ask Chancellor McRaven for the methane emissions reduction task force (Metzger, 2017b). Environment Texas reported sharing new petitions with the Chancellor in December, 2017 including over 1,000 student signatures and 77 faculty signatures and support from many alumni and 15 student organizations (Metzger, 2017b) Student petitioners point to vows from companies like Exxon to reduce emissions; such actions are not as controversial as they might seem (Metzger, 2017b).

Other groups outside of the universities and Environment Texas have also gotten involved. FJC (called "A Foundation of Philanthropic Funds") offered Chancellor McRaven its help in creating a loan program to help replace high-leaking pneumatic devices on University Lands (Metzger, 2017a). FJC is "a public charity that provides total management of charitable giving. To date, FJC has established over 1,000 philanthropic funds and manages over $275 million in assets" (FJC, 2017). FJC points out gas would be saved with the leak prevention devices installed, so once operators save gas and profit, they can use the profit to cover all the costs of the devices (Silverman, 2017). On the other hand, the industry group North Texans for Natural Gas started a counter-petition in Fall of 2016 to oppose the environmentalists' campaign (Mosier, 2016).

University Lands and Environment Texas and petitioners have thus far not conversed or compromised on the topic, to my knowledge. Alyssa Ray, Associate Director of Corporate Strategy and Development of University Lands does not trust Environment Texas's calculations based on EPA data: "'We believe the data that Environment Texas has in the past made public regarding emissions from PUF Lands is misleading,' Ray said in an email. 'This is a common tactic among groups like Environment Texas — to take advantage of a lack of knowledge among the public in order to evoke fear and make things appear a little more 'scary' than they actually are in reality'" (Mendez, 2017a). Mark Houser, CEO of University Lands, expressed a similar sentiment in 2016 (Mosier, 2016). Others doubt University Lands' reasoning, stating "University Lands takes issue with these calculations, suggesting they have 'correct, accurate statistics' that are 'specific' to their lands. However, much of the numbers they cite include similar extrapolations and assumptions as the estimates they criticize. They rely on industry-reported emission data known by researchers to be providing an incomplete picture. UL's data presentation and message on methane emissions does not reflect an approach worthy of a world-class, truth-seeking research institution" (Matiella and Costigan, 2017). Matiella and Costigan (2017) recognize too that University Lands is not requiring the replacement of high-leaking equipment on their lands and has not "even set a goal or target for reducing methane emissions" (Matiella and Costigan, 2017).

University Lands and Texas could look to other states' rules as precedents, especially as federal rules are not promising for now (Lefebvre, 2017). A few states have taken the lead on methane reduction. In 2014, Colorado became the first state to limit methane from oil and gas production, requiring leak fixes and devices that capture 95 percent of methane and volatile organic compounds (VOCs) (Ogburn, 2014). The state's rule is supported by environmental groups and was made with participation from the Environmental Defense Fund and from energy producers (Ogburn, 2014). In 2017, California implemented a similar regulation (California Air Resources Board, 2017). The California Air Resources Board (2017) assures that the new rule "requires quarterly monitoring of methane emissions from oil and gas wells, natural gas processing facilities, compressor stations and other equipment used in the processing and delivery of oil and natural gas. Some equipment will also be required to add vapor collection systems."

California has a 40 percent methane reduction from 2013 levels goal to achieve by 2030; 15 percent of the state's methane emissions come from oil and gas (California Air Resources Board, 2017).

Other important actors in the movement to limit methane emissions from oil and gas production are companies. Exxon is voluntarily taking measures to reduce methane emissions over three years, it announced in September 2017 (Kusnetz, 2017). It will phase out the high-bleed valves on all new and existing projects on both public and private lands (Kusnetz, 2017). It is interesting to note that the company did not speak of climate change in their statement (Kusnetz, 2017).

Retrofitting oil and gas production machinery is a fairly simple, affordable, near-term method University Lands could require from the companies leasing from them to drastically reduce GHG emissions on their land. Especially as studies have shown increases in fracking and the trends in the Gulf Coast and Texas contribute to the methane problem, University Lands should at least consider policies aimed at repairing or replacing the worst performing controllers and machinery that emit the large majority of emissions.

Chapter 3: Peer University Case Study: Boston University

Boston University is a peer research university fairly comparable to UT Austin. I include a case study of Boston University as a successful example of progressive sustainability and climate action initiatives. Some tools exist to assess colleges' and universities' sustainability efforts. Shriberg (2002) conducted research to evaluate some of these tools and recommended identifying important issues, having calculable and comparable assessments, placing significance on reducing or eliminating negative impact, and planning comprehensively in order to address many stakeholders (p. 256-257). Shriberg (2002) outlined strengths and weaknesses for 11 different campus sustainability assessment tools with limited data. The report analysis found that "[while] measuring 'what' campuses are doing and 'how' they are doing it, most assessments neglect 'why' initiatives began and are maintained (i.e. motivations)" (Shriberg, 2002, p. 266). The Boston University Climate Action Plan (CAP) is effective because it explored the "why;" it explained how flooding could affect its buildings and the likelihood that flooding could be worse in the coming decades due to climate change (CATFBU, 2017). On a broader level, the plan came at a time when much of the Boston University (BU) community was pushing for climate action in a variety of ways, indicating the creation of the CAP as an initiative itself was motivated by majority opinions (Barlow, 2016). The CAP evaluated different options and provided priority steps, which are discussed in this chapter. Another study that "explored the factors that influence the integration of sustainability into the operations, teaching and research activities of universities in Australia and England" established that individual actors with drive and interest in sustainability play imperative functions in enacting sustainability-focused actions and policies at universities (Ralph and Stubbs, 2013). Leaders and advocates for sustainability need to be proactive, and staff needs training in order for sustainability at a university to succeed (Ralph and Stubbs, 2013).

I consider these ideals as I look into the sustainability programs and climate action at Boston University and next the University of Virginia, examining how these case studies hold applicable lessons to contribute to and build upon the work at UT Austin. Highlights from BU include partial divestment and the Climate Action Plan, which aims for zero net GHG emissions by 2040 (CATFBU, 2017).

DIVESTMENT: THE PROCESS

Divestment is ending investment funds, stocks, and bonds in something "unethical or morally ambiguous" (Fossil Free, n.d.). Some argue fossil fuel investments fall in that category because of their contributions to environmental problems and climate change. Fossil fuel divestment can be stopping sponsorships of fossil fuels and avoiding new investments in fossil fuels companies; in addition, it might involve removing investments from comingled funds (Fossil Free, n.d.).

Today the word "divestment" is commonly used when talking about universities and fossil fuels. Grady-Benson and Sarathy (2014) found that "relatively smaller endowments" and "institutional values of environmental sustainability and social justice played key roles in colleges' decision to divest." Divestment is a movement extending beyond universities, however. It can be applicable to the investments of companies as well, and in January 2018, Mayor Bill de Blasio of New York City announced the city would divest $5 million in pension funds from companies involved with fossil fuels (Neuman, 2018). At Boston University (BU), divestment was a three-year development. First, the Board of Trustees created the Advisory Committee of Socially Responsible Investing (ACSRI) in April 2013 (Miller, 2017). In September 2014, 245 professors at BU gave

President Robert A. Brown their petition for fossil fuel divestment, complete with research supporting the feasibility and potential benefits of the idea (Miller, 2017). President Brown believed greenhouse gas emissions and climate change are major issues but thought that reliance on fossil fuels in infrastructure and daily life is so substantial that there were better ways to immediately counteract climate change (Barlow, 2014). ACSRI reviewed the faculty petition that December (Miller, 2017). Then, in the spring of 2015, divestment was part of the Student Government election as a referendum poll--to understand opinions but not to form a binding decision (Miller, 2017). It won 75 percent of student votes (Miller, 2017). ACSRI hosted many panels in 2015 and students in support of divestment rallied at their forums (Miller, 2017). In the spring of 2016, ACSRI made the divestment recommendations and plans, and that September the decision was made to partially divest and to complete other actions to reduce the university's environmental impact (Miller, 2017).

BU's arrangement is considered "partial divestment," as it is a promise to avoid investing in coal and tar sands only (Rosen, 2016). Some students and faculty have continued to advocate for complete divestment in fossil fuels, but President Brown wrote a letter stating "[perfect] implementation cannot be assured, however, given the university's inability to have total investment control," because mutual funds, for example, might be invested in fossil fuels (Rosen, 2016). The university had a $1.7 billion total endowment in 2016, which is half the size of the University of Texas at Austin's (U.S. News & World Report, 2018a; U.S. News & World Report, 2018b). On the same day as the partial divestment commitment, ACSRI "further proposed that the University's endowment investment office include managers with expertise in renewable energy sources and technologies" (Barlow, 2016). The group was wise to consider alternative, future-oriented investments, and it also supported the newly written Climate Action Plan and its implementation (Barlow, 2016).

The student group DivestBU was not completely satisfied with partial divestment, and it continues to pressure President Brown and other decision-makers to fully divest (Miller, 2017). Some students see divestment as a campaign to bring the focus of universities back to students' needs and desires, away from profit-making motives (Walrath, 2016). David Shugar, an experienced divestment activist, has a moderate approach that recognizes divestment should be more gradual when it makes sense for a university, and that it is financially feasible, even smart, to remove investments from some fuels such as coal (Walrath, 2016). He thinks universities can try to influence fossil fuel companies as shareholders (Walrath, 2016). Some divestment groups, like the one at Boston College, adjusted their stance to ask for more socially responsible investing (Walrath, 2016). The different arguments are probably more or less applicable at different universities considering state industries, research focuses, endowment makeup, stakeholders, and culture.

The group DivestBU (2017c) has taken on other tasks as well, and they contributed to the Climate Action Plan (CAP), working with Student Government, compiling endorsements from 49 student groups and hundreds of individuals, and holding rallies. The group pressured the eventual decision to set a goal to reduce greenhouse gas emissions at BU by 100 percent by 2040, a program called "BU Bold" in the CAP (Divest BU, 2017c). They use Facebook as one method to reach out to student groups and to share news related to divestment and climate action, provide information about their events, and advertise outside events about activism and organizing (DivestBU, 2017a; DivestBU, 2017b; DivestBU, 2018a; DivestBU, 2018b). In their official press release from early December 2017 in reaction to the passing of the Climate Action Plan with the BU Bold proposal, the group expressed support for the plan and framed it with aspirations for equity, calling the plan "morally necessary" to prevent further harm to "the world's most vulnerable" facing climate change (DivestBU, 2017c). DivestBU refers to the CAP approval as one step of many and promises to keep "pushing BU to further its climate leadership and divest from fossil fuels" (DivestBU, 2017c). BU's partial divestment decision puts it among only a handful of medium-to-large American universities that have divested or partially divested, and its Climate Action Plan deepens its pledge to be responsible for the future of the campus and its surroundings.

THE CLIMATE ACTION PLAN

Boston University published its Climate Action Plan in December 2017. The Climate Action Task Force led the plan's creation since the fall of 2016 (Climate Action Task Force at Boston University [CATFBU], 2017). Like Texas, Boston is threatened by climate change. For Boston, the biggest hazard is sea level rise, while Texas is most affected by heat waves, drought, and floods, as well as hurricanes, wildfires, and other natural disasters (Bridging Barriers, 2018).

BU's Climate Action Task Force is divided into four working groups, including Energy (CATFBU, 2017). The topic of energy is included throughout the Climate Action Plan. The Plan included the BU Bold scenario, which achieves 100 percent net zero GHG emissions by 2040 and aims for 100 percent renewable energy after 2018 (see Figure 2.1) (CATFBU, 2017, p. 13-14). The City of Boston aims to be carbon neutral ten years later, by 2050 (CATFBU, 2017). The implementation of BU Bold would mean energy adjustments in nearly 70 buildings and the requirement for all new buildings to achieve LEED Gold certification (CATFBU, 2017). Task force chair and faculty member Anthony Janetos thinks it is time for renewable energy at BU: "Increasing competition in that sector has brought down market prices, and costs are even lower than they were a year ago when the task force began its work” (Woolhouse, 2017). However, the university cannot achieve net zero emissions through internal actions only; the BU Bold target would involve some fossil fuel use and some purchase of certified offsets (CATFBU, 2017). “A power purchasing agreement (PPA) will allow the University to begin purchasing renewable energy immediately while beginning its longer-term effort to increase its end-use efficiency” (CATFBU, 2017). Offsets work in the following way:

“An accounting device known as a renewable energy certificate (REC) is used to keep track of renewable energy transactions, and the RECs are then retired. A REC is a contractual instrument equivalent to one megawatt-hour of renewable energy generation on the electricity grid. RECs are the sole means to claim usage of grid-connected renewable electricity in the US and are used for compliance with the Renewable Portfolio Standards within the US. By retiring the REC, no one else can also claim credit for the same renewable energy, thus avoiding double-counting. For the University to have confidence that double-counting is avoided, the RECs will be Green-e Certified.” (CATFBU, 2017, p. 15)

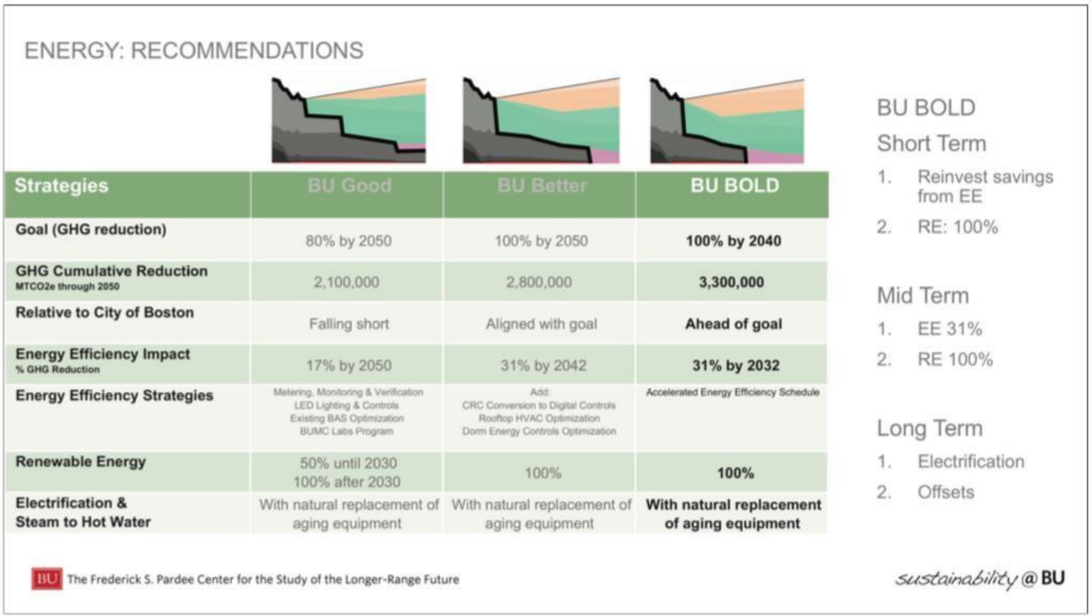


Figure 3.1 (CATFBU, 2017) Timeline of the recommended BU climate action scenario.

The plan had plenty of focus on climate change and potential flooding, recognizing the increases in risks as the climate changes over the years, and looked at Boston's possible flood events as far away as 2070 (CATFBU, 2017). Floods have expensive consequences; the BU buildings at risk would cost \$65 to \$75 per square foot to repair (CATFBU, 2017, p. 17). BU has 500-year flood insurance to try to mitigate against flood threats (CATFBU,
2017). The plan suggested moving indispensable research items in danger of damage from basements with flood risk (CATFBU, 2017). It paid special attention to resilience, calling for investments in "portable flood barriers" that would prevent some of the flood water damage that would result from 1-in-100-year flooding events, especially at locations with highly relevant risks and resulting costs (CATFBU, 2017, p. 18).

The Climate Action Task Force (2017) also explored how emissions from traffic, other air pollution, heat waves, and other damage can be problematic and not entirely preventable. The plan recommended hiring a fulltime staff member "to coordinate resilience actions and prepare a plan for enhancing the University's resilience over the coming decades" (CATFBU, 2017, p. 19). Climate action at BU is clearly not only about environmental protection and basic climate resiliency; it also promotes health and safety for people. For example, the plan indicated dorms that need air conditioners (CATFBU, 2017). BU considers not just big-picture effects but recognizes how the people in and around its campus community might be harmed by a changing climate and intensified and increased natural disasters.

The plan mainly focused on Scope 1 or Scope 2 emissions, direct emissions and emissions incurred as a consequence of our purchases of electricity" (CATFBU, 2017, p. 20). The EPA has definitions for Scope 1, Scope 2, and Scope 3 GHG emissions (2018). Scope 1 are

> direct emissions from sources that are owned or controlled by the Agency. Scope 1 includes on-site fossil fuel combustion and fleet fuel consumption. Scope 2 GHG emissions are indirect emissions from sources that are owned or controlled by the Agency. Scope 2 includes emissions that result from the generation of electricity, heat or steam purchased by the Agency from a utility provider. Scope 3 GHG emissions are from sources not owned or directly controlled by EPA but related to Agency activities. Scope 3 emissions include employee travel and commuting. Scope 3 also includes emissions associated with contracted solid waste disposal and wastewater treatment. Some Scope 3 emissions can also result from transportation and distribution (T&D) losses associated with purchased electricity. (Environmental Protection Agency [EPA], 2018)

These totaled approximately 129,400 metric tons of CO2-equivalents in 2016 (CATFBU, 2017, p. 10). This contrasts with UT, where almost all of the electricity comes from the onsite natural gas plant and campus emissions have held steady since the 1970s

(The University of Texas at Austin, 2016). Scope 3 emissions are those from transportation, waste, and emissions connected to materials purchasing (CATFBU, 2017). BU's plan recommended a few transportation pilots, such as Electric Vehicles on a small scale in 2020 and electric buses in 2022 (CATFBU, 2017, p. 21). Other goals addressed the impacts of purchasing and materials: "we recommend that the University pursue Zero Waste Certification on a pilot basis with the US Zero Waste Business Council, and establish a Zero Waste Sustainability goal (which in reality means that 90% of our waste would be diverted away from landfills, including 90% of construction waste)" (CATFBU, 2017, p. 22). The Climate Action Task Force (2017) also expressed hope that each undergraduate student had "exposure to some aspect of these issues before they graduate" (p. 23). Other academic goals included a proposal for an "Initiative on Climate Change and Sustainability" centered on research and conferences (CATFBU, 2017, p. 24). The task force already plans for the Climate Action Plan to be updated every ten years (CATFBU, 2017, p. 26). The Climate Action Plan is progressive, future-oriented, and comprehensive, has rationalized priorities, and is relevant to the school's location.

CONCLUSION

Of course, BU is different from UT Austin in ways that increase the feasibility and success of its partial divestment. Among the universities' similarities, however, are that they are urban campuses that were founded in the 1800s (U.S. News & World Report, 2018a; U.S. News & World Report, 2018b). UT is a very large school with a student body of around 51,000, and BU is fairly large at about 33,000 students (U.S. News & World Report, 2018b).

The two schools are similarly reputable, as according to the U.S. News & World Report (2018b), UT Austin ranks 56th in national universities and 18th in public schools, and BU is 37th in national universities; however, BU is a private school (U.S. News & World Report, 2018a). Private schools have different avenues available to make actions for divestment, energy sourcing decisions, and sustainability goals as they do not have to abide by state system rules or vie for state money. Thus, it is rational to think that UT Austin could not have a successful fossil fuel divestment campaign as quickly, even if it was located in a state with a different economy. Both UT and BU are considered Tier One research universities by the Association of American Universities (n.d.). As mentioned before, UT Austin's endowment at $3.4 billion in 2016 is twice as large as BU's (U.S. News & World Report, 2018b). Additionally, the academic department focuses play into the social and cultural environments of the universities and the likelihood that something like fossil fuel divestment could work. UT is ranked second of eight schools offering degrees through doctorate level in Petroleum Engineering, just behind Texas A&M (U.S. News & World Report, 2018b). State industries also affect how decisions at a university are made. Petroleum and gas extraction is the largest industry in Texas, and Texas is the U.S. state with the most extraction by far (Stebbins, 2017) It produced $160.4 billion of the gross domestic product (GDP) in 2015, which was 10.7 percent of the state GDP (Stebbins, 2017). The industry employed over 99,000 people in Texas (Stebbins, 2017). On the other hand, Massachusetts has no oil or gas reserves (BallotPedia, 2018). The only potential near-future extraction would be off the coast of Massachusetts. Among industries the state is known for are hospitals, medical and nursing facilities, and medical education (Stebbins, 2017). The reaction to divestment in Massachusetts was reasonably more accommodating than it would be in a state like Texas; a divestment campaign would be inconsequential at UT where not only does the PUF rely upon it, but so much of the statewide employment and economy is connected to oil and gas extraction.

One benefit of the large Permanent University Fund at UT is it helps maintain relatively low costs for the school and enables UT to avoid pushing the burden to students through tuition hikes. Tuition and fees at UT are about $10,136 at the in-state level and about $35,766 for out-of-state in 2017-2018, compared to about $52,082 at BU, which is a private school (U.S. News & World Report, 2018b; U.S. News & World Report, 2018a). The PUF helps enable UT Austin to preserve low tuition for students and support research projects that benefit the broader community. There are some tradeoffs to consider in decisions around sustainability and environmental impact.

As mentioned before, like Texas, Boston is threatened by climate change. For Boston, the likelihood of sea level rise is the biggest threat. Official city planning is currently steered by predictions that as much as 30 percent of the city could be underwater by 2100 (Abel and Logan, 2018). For Texas, sea level rise is also a threat, and other climate change effects threaten the city of Austin. According to Hayhoe, (2014), "by 2041-2070 there are projected to be" about 25 to 50 more 100-degree plus days annually, depending on the scenario used (p. 4). The study also predicts "more frequent extreme precipitation" and "more frequent drought conditions in summer due to hotter weather" with average annual rainfall remaining about the same (Hayhoe, 2014). The state also suffers from hurricanes and wildfires that could occur more often with more extreme weather conditions and droughts. To sum up, UT Austin should take measures to reasonably and appropriately lower emissions and lessen its environmental impacts in ways that are possible and compatible with current actions and programs.

UT Austin can learn several lessons from BU. UT is well-equipped in its sustainability programs, events, and student involvement, its efficient natural gas plant, and its Campus Master Plan and Sustainability Master Plan. These competencies could be strengthened by decision making at the school-wide and system-wide level. UT should address the role of University Lands more often and more directly, aim for better transparency, and consider creating its own Climate Action Plan. The Sustainability Master Plan says nothing of University Lands, "oil," or "fossil fuels." It only mentions "natural gas" when describing the onsite power plant. With as much as 20 percent of UT Austin's endowment coming from University Lands profits (or 9 percent of the budget), it seems vital that the role is discussed in a document about sustainability (Roush, 2017). The Office of Sustainability will publish a Sustainability Master Plan progress report this year in 2018 at the two-year mark, and the next updated plan will be in 2021 (The University of Texas at Austin, 2016, p. 18). The Sustainability Master Plan hints at the "why" of the plan—the goals to be a leader among public research universities, to build resiliency as "uncertainties [face] future generations," and to uphold "inclusivity" (The University of Texas at Austin, 2016). Even if the Sustainability Master Plan is meant to be purely campus-specific, other sectors of UT Austin should be open to drawing attention to University Lands in a formal report about sustainability.

UT Austin faculty petitioned to Chancellor McRaven to have a taskforce to address methane emissions on University Lands. This task force would increase transparency in the decision-making processes of UT and the UT System. It could be an extension of the President's Sustainability Steering Committee or separate from it. BU created the ACSRI in response to the divestment campaign, and it provided more regular updates on the thought-process and considerations related to divestment and ultimately led to the creation of the Climate Action Plan. A task force at UT Austin could make recommendations about methane controls and other concerns with University Lands, and these actions could contribute to a UT Austin Climate Action Plan at a later date. Another important model for transparency from BU was the student referendum, and UT could borrow this idea to address methane emissions and give the new task force ideas about support and confusion within the campus community.

UT's Climate Action Plan would be a document in which the university can brag about its successes like the power plant's efficiency, and it could build from existing projects, such as the Carbon Roadshow. A Climate Action Plan could address is issues brought about in the Campus Master Plan, helping UT grow wisely while addressing climate change resiliency in its built form. UT Austin contributors could find strength in the well-established academic programs and connections to fossil fuel development. Even though divestment is not viable, the university could encourage University Lands and companies leasing its land to use better practices like technology to prevent methane leaks and sequestering carbon. UT Austin should be a leader in sustainability in energy production because of its strong connections to oil and gas, not separate from them. I see UT Austin's ties to fossil fuel production as an opportunity rather than a limitation.

Chapter 4: Peer University Case Study: University of Virginia

Some highlights of sustainability at the University of Virginia include the Sustainability Plan, on-campus solar energy installations, and research and policies to reduce the campus's nitrogen footprint. The context of the University Virginia (UVA) is not exactly like that of UT Austin or BU. It is a state public university, but Virginia does not have the oil and gas industry background that UT and Texas have. UVA has not had a successful divestment movement as BU has, and Virginia is not a state known to be as progressive as Massachusetts. It is similar to UT in its participation in various nationwide sustainability programs. In this chapter, I summarize many of UVA's sustainability and environmentally-oriented initiatives to see what lessons might apply to the UT context.

Overview of Programs and Accomplishments

Sustainability at the University of Virginia consists of the Committee on Sustainability, which counsels the Executive Vice Presidents on the university's sustainability commitments, the Office for Sustainability within Facilities Management, and various student organizations. The Office for Sustainability runs the Sustainability Advocates student program, meant to "instill knowledge, empower students, and create awareness of the impact of daily decisions" between peers (UVA Office for Sustainability, 2018). The Office for Sustainability also houses Green Labs, a program that lessens the impact of water, energy, and material intensive science labs, and a Green Workplace program for implementing sustainability initiatives at staff offices (University of Virginia [UVA] Office for Sustainability, 2017a; The office also manages Sustainability Partners, through which staff can lead and influence sustainability initiatives at the university (UVA Office for Sustainability, 2017b).

In 2016, the Association for the Advancement of Sustainability in Higher Education (AASHE) awarded UVA the second place in "Diversity and Affordability" based on STARS, Sustainability Tracking, Assessment & Rating System (Heuchert, 2016). UVA received a rank of 45 out of Princeton Review's top 50 Green Schools in 2017 and also ranked 59th in Sierra Club's Cool Schools list of 2017, for which schools can earn points for having a committee on responsible investments, for being energy efficient, and for using renewable energy among many other criteria; however, it is important to clarify that schools submit the data voluntarily themselves for each list (Sierra Club, 2017a; Sierra Club, 2017b; Princeton Review, 2017). For the 2017 GameDay Challenge, a recycling initiative where colleges nationwide compete at one football tailgate each fall, UVA won third place in total recycled amount and tenth place in diversion rate, and UT Austin got fifth place in recycled amount and 20th place in diversion rate (Game Day Challenge, 2018). Both schools have a commitment to these prominent, organized events that are supported by student time commitment and dedication. The strength and enthusiasm the universities have for organization and events could transfer to new policy and institutional changes that support future-oriented sustainability principles, as well.

The University of Virginia has increased sustainability efforts in the realm of food in recent years. Central Virginia is an agricultural region. The state as a whole has 32 percent of its land covered by farms, over 50,000 jobs in agricultural production, and a variety of products and livestock distributed nationwide (Virginia Department of Agriculture and Consumer Services, 2018). The Sustainable Food Strategy Task Force published an annual report in 2017. The task force has existed since 2016 and is a part of the Dining Working Group of UVA Sustainability (Sustainable Food Strategy Task Force, 2017). Activities include waste reduction, recycling, composting, getting officially certified sustainable seafood, assessing the nitrogen footprint of the university, raising awareness via film features, and running a 3,000-acre student-run farm, the Morven Kitchen Garden (Sustainable Food Strategy Task Force, 2017).

The report recognizes the opportunity to make more sustainable purchases of meat, since at this time only just over 11 percent of meat is AASHE STARS sustainable certified (Sustainable Food Strategy Task Force, 2017, p. 5). Of all food purchases, less than 7 percent were deemed “sustainable” in 2015 (Sustainable Food Strategy Task Force, 2017). UVA Dining wants to accomplish 50 percent sustainable food purchases by 2034 (Sustainable Food Strategy Task Force, 2017, p. 5). In 2017, UVA’s Sustainable Food Strategy Task Force hosted the Virginia Higher Education Sustainable Food Supply Chain Symposium which brought together stakeholders from the university and various suppliers and producers (Krantz, 2018). UVA is located in an agricultural region, and there is high interest in and support for food sustainability, access, health, and policy in the sustainability and urban planning realms of the university. UVA thus has an opportunity to push these goals even further and to expand its sustainability efforts related to food.

One of UVA’s most prominent sustainability successes is being the first campus to measure its nitrogen footprint, which was led by Dr. James Galloway, a professor of Environmental Sciences, and Allison Leach, who was a graduate student at the time in 2013 (Perez, 2017). The university aims to reduce emissions of reactive nitrogen by 25 percent by 2025, a goal approved by the Board of Visitors in 2013 (The University of Virginia, 2017a; Perez, 2017). Reactive nitrogen “creates smog, acidifies water sources and weakens the upper-atmospheric ozone layer” (Perez, 2017). Nitrogen emissions largely come from energy use and food, but also from transportation, research animals, and fertilizer at universities (Leach et al., 2013; Perez, 2017). The research team revealed how reducing food waste and more conscientious protein intake can reduce reactive nitrogen emissions (Shibata et al., 2016). UVA was the frontrunner and leader among university efforts to tackle nitrogen emissions, and by 2017, there were 20 other institutions joining it in measuring and reducing their nitrogen footprints (Perez, 2017). Now, the "Nitrogen Footprint Tool Network is working with the University of New Hampshire Sustainability Institute to build the nitrogen footprint tool into the Campus Carbon Calculator. ...this tool will enable institutions to calculate their nitrogen and carbon footprints together." (Perez, 2017). Sustainability: The Journal of Record (2017) had a special April 2017 issue in which universities' roles in nitrogen pollution and reduction are described in several articles. UVA played a primary role in bringing this issue to the forefront and reminds scholars and university communities that there are multiple kinds of emissions and environmentally damaging practices.

UVA has an active student group called Virginia Student Environmental Coalition, Charlottesville (formerly Climate Action Society) that organizes, educates peers, and protests environmental and climate injustices or controversies like proposed pipelines in contentious locations (Divest UVa, 2017). In 2016 they had a campaign, Divest Uva, but it has not been as active recently as it was a few years ago (Divest UVa, 2016). Like UT and BU, UVA has various interrelated groups and efforts around support for sustainability and environmental protection.

UVA Sustainability Plan

Like UT Austin, UVA also has had a presidential sustainability committee since 2008 and published Sustainability Plan document (The University of Virginia, 2016a). Nina Morris, the Sustainability Outreach & Engagement Manager, said the Sustainability Plan is the biggest success of sustainability at UVA over the past couple of years. She said "it brought UVA together toward a shared vision on how we wanted to move towards a sustainable future and effectively communicate what progress looks like to us. By setting goals and actions in three major areas of Engage, Steward & Discover, we were able to concurrently accelerate the adoption of sustainable practices in our operations, our curriculum, our research and our community" (Morris, personal communication, March 2018). Included in the "Engage, Steward & Discover" focuses, the plan covers emissions data and renewable energy goals well and references climate change.

UVA, like the other universities, set emissions reductions goals and tracks progress and measures Scope 1, 2, and 3 emissions. Overall, UVA provided timely, transparent, hard data. In 2009, a goal was set to achieve GHG emissions levels 25 percent below those in 2009 by 2025 (The University of Virginia, 2016a, p. 18). The university accomplished seven percent as of 2015—so 28 percent of the goal in 38 percent of the time allotted (The University of Virginia, 2016a, p. 18). Meanwhile at UT, carbon emissions are higher than those of its peers, but the campus goal of reducing building energy use by 20 percent from 2009 to 2020 is likely to be on target, and the carbon emissions levels in 2016 were equal to those in 1977 (The University of Texas at Austin, 2016, p. 49; Texas Architecture, 2017). The University of Virginia 2016 Greenhouse Gas Inventory Report checked progress on its reduction goals. Like the other universities, it delved into Scope 1, Scope 2, and Scope 3 emissions (The University of Virginia, 2016b). Scope 3 emissions included faculty, staff student commuting, however, because there is not a reporting system some Scope 3 emissions were not included (The University of Virginia, 2016b, p. 6). The method for measuring considered carbon dioxide, methane, nitrous oxide, and refrigerants as metric tons of carbon dioxide equivalent using the Global Warming Potentials provided by the Intergovernmental Panel on Climate Change. It described emissions from electricity, fuel, transportation, and operations support (The University of Virginia, 2016b, p. 5). The majority of Scope 1 emissions came from stationary fuels on campus used for heating, especially coal, although that went down 68.7 percent from 2009 to 2016 (The University of Virginia, 2016b, p. 13-14). Transportation emissions are increasing gradually, particularly as its population grows (The University of Virginia, 2016b).

Plant improvements and efficiency have led the effort in GHG reduction at UVA so far, with actions like lowering "building energy use intensity 20% below 2010 levels by 2020" (The University of Virginia, 2016a, p. 19). According to the UVA Sustainability Annual Report for 2016-2017, energy intensity use had achieved a 9.2 percent reduction so far (The University of Virginia, 2017b, p. 8). The plan also aimed to increase the portion of energy that comes from renewable sources and to give Facilities Management the authority to use a "portfolio to supplement the voluntary version the state has" by 2020 (The University of Virginia, 2016a, p. 19). The campus has solar panels at a library and three other buildings with over 500 kwh at peak capacity; this is estimated to grow to approximately 2,000 kW-AC of PB and solar thermal combined installed by 2025, and the school plans to purchase offsite renewable energy (The University of Virginia, 2016b; The University of Virginia Facilities Management, 2018; The University of Virginia, 2017b, p. 48). The online Renewable Energy Tracker shows real time and cumulative solar power production and the cumulative carbon dioxide offset (The University of Virginia Facilities Management, 2018). Like Boston University, UVA has formed Power Purchase Agreements. Those with Dominion Power in 2016 and 2017 committed the school "to purchase 100 percent of the output of two new utility-scale solar power projects. When completed in late 2018, these two projects will generate enough solar power to offset 21 percent of UVA's power consumption and 32,000 MTCDE of its greenhouse gas emissions each year" (The University of Virginia, 2017b, p. 48). As of February 1, 2018, the total solar power production across UVA's campus since 2015 was 698 megawatt hours (MWh), with 327 metric tons of carbon dioxide avoided (The University of Virginia Facilities Management, 2018). Nina Morris says of solar: "We've seen a lot of engagement from our community in support of these initiatives and we’ve gotten UVA classes involved in the site selection and implementation of solar” (2018). Further, the campus plans to shift away from coal entirely within the ten years following 2016 (The University of Virginia, 2016a, p. 19).

The plan also tasked Facilities Management with finding ways to reduce waste heat and they almost immediately produced results (The University of Virginia, 2016a, p. 19). “Having completed its first full year of operation since its conversion to a low temperature hot water plant with heat recovery units, the North Grounds Mechanical Plant is using almost half the energy and 10 percent less water than it did when operating with the old conventional boilers and chillers” (The University of Virginia, 2017b, p. 46). Additionally, the UVA 2016 Greenhouse Gas Inventory Report aimed to optimize heating plants between 2017 and 2019 ((The University of Virginia, 2016b).

The Sustainability Plan addressed climate change with the charge to outline the campus’s climate change vulnerability and to “identify methods to increase resiliency” by 2017, directed by the Committee on Sustainability (The University of Virginia, 2016a, p. 20). The Darden School of Business, the graduate business school, and the McIntire School, the undergraduate business school, have taken the lead on climate change in the curriculum. Darden has a Business Innovation and Climate Change Initiative, a program focused on education and discovery of “the intersections between business and public policy in regards to addressing climate change” which will be home to a fellowship program and will hold regular events and summits oriented around innovation and leadership, and McIntire has a Certificate of Sustainable Business that includes focuses on energy and climate change (The University of Virginia, 2017b, p. 65).

CONCLUSION

UVA is academically competitive with UT, and the two universities have an opportunity to contend in sustainability action as well, in terms of energy plant and building efficiency, on-campus renewables, and initiatives like the Game Challenge recycling. UVA was ranked 25th in national universities and 3rd in public schools by the 2018 U.S. News and World Report (2018c). The endowment of the University of Virginia, surprisingly, is larger than UT's--$5.8 billion compared to $3.4 billion, in 2016--but that number does not account for the additional benefit UT Austin gets from maintenance and support of UT System Administration from the Permanent University Fund (U.S. News & World Report, 2018b; U.S. News & World Report, 2018c). These are comparable schools which I expect have comparable expectations from their students and communities.

Academic strengths at UVA include 7th in best undergraduate business programs, a match to UT's 5th place rank, but UVA lacks the focus on petroleum engineering that UT has (U.S. News & World Report, 2018b; U.S. News & World Report, 2018c). Unlike Massachusetts, there is fairly prevalent fossil fuel extraction in Virginia. Coal is mined in a small area in southwest Virginia (Gilmer et al., 2005). Nearby, there is some coalbed methane and conventional natural gas extraction, and there is crude oil extraction in a couple of counties, but oil and gas production is nowhere near as extensive as it is in Texas (Gilmer et al., 2005). The effect on the overall state economy is smaller; rather, Virginia is one of the states with the most varied economy and without a very large industry dominating a large portion of GDP (Stebbins, 2017). Administrative and support services account for just 3.6 percent of GDP in 2015 although it was the largest industry behind real estate (Stebbins, 2017).

Like the comparison with BU, UT is able to keep tuition $6,000 to $11,000 lower than UVA's, but it is difficult to prove causation between the PUF and lowered costs (U.S.

News & World Report, 2018b; U.S. News & World Report, 2018c). Additionally, UT might face challenges in organizing students given its massive size, whereas UVA has a smaller audience to reach with just over 16,000 undergraduates (U.S. News & World Report, 2018c).

UVA is a public school subject to state policies and, like UT, is likely unable to "divest" anytime soon. Nina Morris responded to my questions about climate change, saying that "In terms of emergency preparedness, I know UVA is undergoing a lot of change in our leadership which may impact how much climate change is included in our planning process for emergencies" (2018). She says their "biggest challenge is time— we're working as fast as we can to accelerate sustainable practices in alignment with the mission of UVA, but there is always more work to be done build a sustainable UVA. As our knowledge grows around the impacts of climate change and other major challenges, so does the urgency to identify and implement new initiatives that can negate and ideally improve our world. A continuing challenge is building sustainability literacy into the fabric of our community" (Morris, 2018).

Both UT and UVA have strong leadership from within the offices responsible for sustainability, as well as notable student programmatic support and research support. UT Austin should apply to more national programs to be recognized as a leader in sustainability as actions such as those in the Sustainability Master Plan continue to develop. Going back to the "why" of policies and programs, UVA is a model for successfully tying research to action. For example, studying nitrogen emissions has been linked to informing the Food Strategy Task Force on their policies. UT can follow this example, particularly with projects like the University Lands project that is broad-reaching. If specific ideas within our University Lands project were picked up by UT Austin researchers who are experts in very particular topics in their fields, their research could become as well-known as the

UVA nitrogen research and it could help improve environmental conditions and reduce emissions on University Lands while increasing revenue from them.

Chapter 5: Solar and Wind Energy

This chapter explores the background of solar energy and wind energy and how solar photovoltaic and wind plants could be a part of the offsetting and reduction plans for University Lands. I describe the work my coworker Mark Reid and I are doing at the Center for Sustainable Development. According to Environment America, renewable energy is defined as an energy source that creates very little or no pollution, is regenerative and nearly "unlimited," safe in terms of environmental and public health effects, and is efficient in exhaustion of resources (Madsen and Sargent, 2016, p. 20). Solar and wind produce minimal emissions, most of which is in the upstream phase (Rhodes, 2017). Solar photovoltaic energy and wind energy both do not require water for cooling (Rhodes et al., 2016).

SOLAR ENERGY

Solar power can be used to create electricity with either solar thermal energy, with which solar heat heats water to create electricity, or solar photovoltaic (PV), which can be placed on rooftops on residences or commercial buildings or can be mounted on ground surfaces at utility-scale plants. The University Lands project explores how utility-scale PV could possibly be implemented on some of the West Texas University Lands. A solar PV plant consists of cells and cells make up a module, and modules are connected as "strings" (International Finance Corporation [IFC], 2015, p. 24). Cells are either thin-film or crystalline silicon (International Finance Corporation [IFC], 2015, p. 25). PV cells are either fixed in place or are on frames that track the sun. The fixed track modules have the benefits of easier installation, lower costs, and minimal maintenance (International Finance Corporation [IFC], 2015, p. 23). Single-axis and dual-axis tracking systems, though, can have up to 27 percent and 45 percent greater energy yield, respectively (International

Finance Corporation [IFC], 2015, p. 34) Single-axis tracking systems can change by orientation or by tilt-angle but not both, while dual-axis tracking do both. Most of the latter directly track the sun through the day (International Finance Corporation [IFC], 2015, p. 33). Inverters convert direct current electricity into AC electricity (International Finance Corporation [IFC], 2015, p. 23)

Compared to wind farms, solar plants generally require less land and often result in fewer negative externalities (Anwarzaia and Nagasakad, 2017, pg. 155). Large solar PV plants use 7.9 to 8.9 acres in total per megawatt alternating current capacity-weighted, on average considering fixed, single- and double-axis design (Ong et al., 2013). Wind farms take up much more land overall, 85.24 acres per megawatt capacity as a legal boundary, and cattle grazing, farming, etc. can happen dually on these lands (U.S. DOE, 2015). Only 0.74 acres per megawatt of this is operational impacted land where turbines stands, thus land use requirements are challenging to compare (U.S. DOE, 2015). Solar power is applauded for lacking noise nuisance that can be a problem with wind farms (although this consideration is less relevant in wide open rural areas) and for being the most abundant energy source (Go Solar Texas, 2017). Additionally, producing solar energy is getting more affordable; prices for solar fell 55 percent in Texas from 2011 to 2016 (SEIA, 2018b). Unfortunately, solar production precludes oil and gas development because of the full surface of land it takes up. Thus, solar might be best for areas depleted of all other resources. Additionally, the feasibility of solar might depend on the existence and costs of transmission lines, roads, and other necessary infrastructure. One limitation to the solar PV utility scale technology is that a plant typically lasts around 25 years, which is usually shorter than a coal plant or a nuclear plant, etc. (Balfour, 2017). A typical utility scale coal or natural gas plant has a 25- to 40-year lifetime, and a typical nuclear plant lasts for 40 to 60 years (Webber, 2015).

NATIONWIDE TRENDS

Around 1 to 2 percent of energy generation in U.S. is from solar, including all types of PV and solar thermal (Energy Information Administration, 2017; The Solar Foundation, 2018). According to the Solar Jobs Census of 2017 by The Solar Foundation (2018), over 250,000 people are employed in the solar industry in the United States. This employment grew by 110% from 2012 to 2017 (The Solar Foundation, 2018). This was nine times the rate of employment growth in the general U.S. economy (The Solar Foundation, 2018). Thus, even though solar is such a small fraction of energy production, it employed "twice as many workers as the coal industry, almost five times as many as nuclear power, and nearly as many workers as the natural gas industry" in 2016 (The Solar Foundation, 2018).

Government incentives help make solar and wind more viable. These include an investment tax credit, Renewable Portfolio Standards (RPS), net metering, capital subsidies, and other tax credits (World Energy Council, 2016). There is a robust market for utility scale solar especially with these incentives (Conca, 2017). Energy experts predicted that federal tax credits for renewable energy like solar and wind would not be taken away, even in the Trump Era (Conca, 2017). This seems to be correct, as the original House tax bill would have cut wind tax incentive programs as they existed, but that was changed in the version that passed in December:

"But the law contains a new provision, called the Base Erosion Anti-Abuse Tax (BEAT), which limits companies' use of renewable-energy tax credits to offset their foreign-transaction taxes, to 80 percent of the credits' value, down from 100 percent previously. That change, along with the reduction in the overall corporate tax rate, to 21 percent from 35 percent — while positive for companies generally—will reduce the usefulness of renewable-energy tax credits to investors, which could increase costs for some renewable-energy developers, some analysts predict." (Sweet, 2018)

The federal solar Investment Tax Credit is a major incentive, “a 30 percent federal tax credit claimed against the tax liability of residential (Section 25D) and commercial and utility (Section 48) investors in solar energy property” (Solar Energy Industries Association [SEIA], 2018a). It is gradually declining and will drop to 10 percent for utility after 2021(SEIA, 2018a). Notably, according to data from the National Renewable Energy Laboratory (NREL) of the U.S. Department of Energy, the “technical potential” for utility-scale solar PV nationwide in 2016 was actually more than 75 times the total of U.S. energy consumption (Madsen and Sargent, 2016). Thus, nothing but growth in solar should be expected in the years to come as existing hurdles are gradually eliminated by improved technologies.

IN THE WEST TEXAS REGION

Texas and West Texas especially have not fully utilized their potential for solar power production. According to the Solar Energy Industries Association (2018b), currently only 0.62 percent of Texas’s electricity comes from solar. This is equivalent to less than 1,900 megawatts of installed solar as of 2017 (SEIA, 2018b). The state has 98 manufacturers, 219 installers/developers, and 197 other solar companies, including 26 utility-scale solar power plants, of the 416 total power plants in Texas (SEIA, 2018b; Energy Information Administration [EIA], 2017). Nine of these solar power plants are in West Texas and seven are in counties that contain University Lands, as shown in Figure 5.1 (EIA, 2017a). These numbers are low compared to the vast potential for solar power production in Texas and West Texas especially.

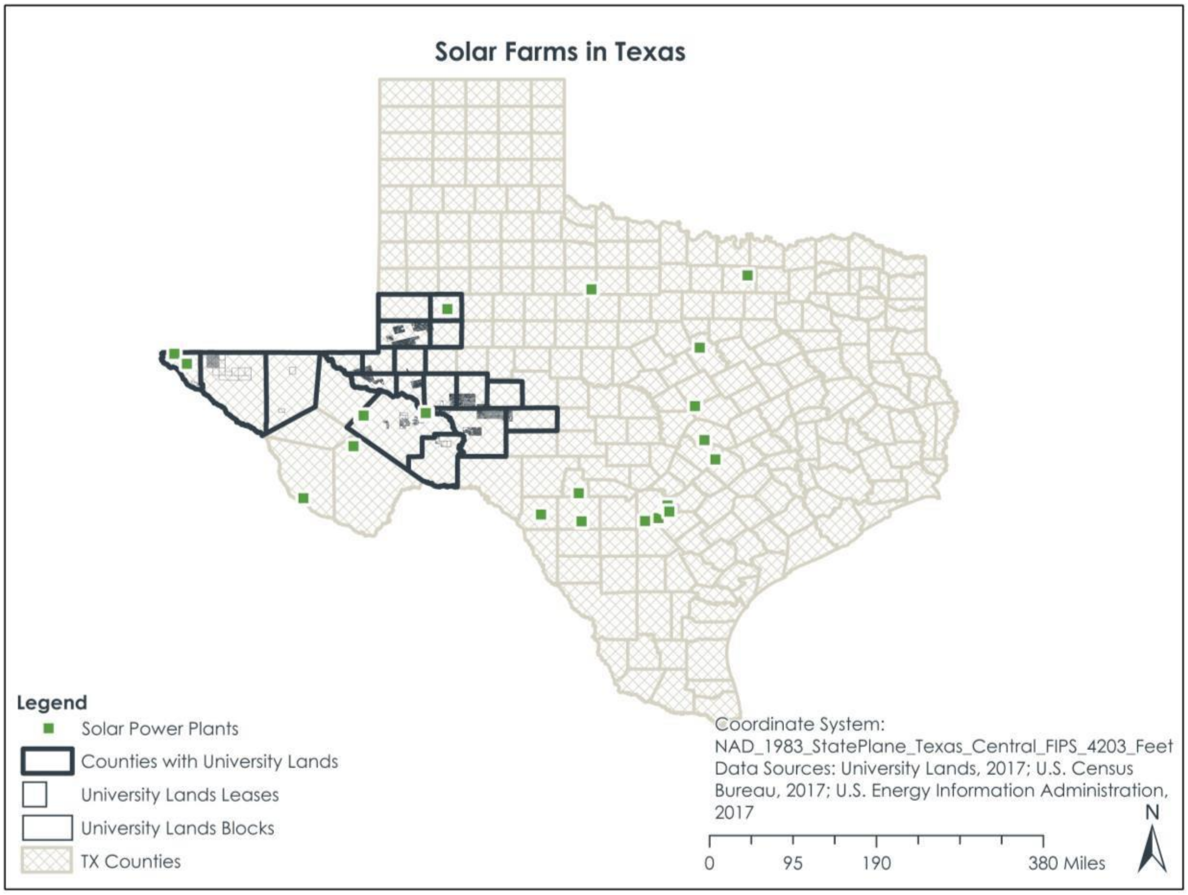


Figure 5.1 (EIA, 2017a) Existing Solar Farms in Texas.

Photovoltaics have grown a lot in TX since 2015 and are expected to continue to grow each year over the next several years (SEIA, 2018b). The Midway Solar Farm, to be completed at the end of 2018 near Midland in Pecos County (which is very close to University Lands headquarters), will be the largest solar farm in Texas. Its power will be bought by Austin Energy (Bubenik, 2018). Examples in Texas other than power plants and residential installments include several large retailers with commercial rooftop installations, such as Applied Materials, Campbell's Soup, and FedEx (SEIA, 2018b).

There are over 8,800 existing solar jobs in Texas within those over 500 solar businesses (SEIA, 2018b). Workers in the energy sector have opportunities to shift from one energy source to the next, and the movement towards clean renewable energy can help workers replace their jobs lost. This is especially relevant today as coal use decreases nationwide. Where working in the fossil fuel industry several years from now might be fickle, it is likely that solar power will keep growing. In Pecos County in 2015, 300 to 400 workers lost their jobs in oil. Since then, most of them have gotten jobs installing solar panels at five solar farms in the county (Handy, 2017). Job positions in the solar industry include Project Engineers, Atmospheric Scientists and Meteorologists, Resource Assessment Specialists and Site Evaluators, Environmental Consultants, and more (International Labour Office, 2011). There is potential for community college training for renewable energy jobs through programs like The American Association of Community Colleges' Sustainability Education and Economy Development (SEED) Center, "a resource center and networking tool devoted to supporting community colleges in building quality green workforce development programs" (Public Policy Associates, Inc., 2010). Most of these jobs are not subject to being lost; they are only going to grow in the foreseeable future.

In August 2017, the Texas Public Utility Commission did away with one impediment to solar in Texas, making a settlement with Oncor, the largest utility in the state, to stop it from implementing a "solar tax," a fee that would make solar for residents more expensive (Hall, 2017). In addition to the federal incentives previously described, the state of Texas has myriad incentives of its own, including property tax rebates and performance-based incentives (Clean Energy Authority, 2018). Utilities are not ordered by legislation but are free to offer net metering if they wish, and many do (Clean Energy Authority, 2018). Texas companies receive an exemption from the franchise tax if they only manufacture, install, or sell solar or wind devices and regular Texas companies can deduct the cost of a solar device from the franchise tax (DSIRE, 2015a; DSIRE, 2015b). The state also has a Renewable Portfolio Standard, which had a goal that by 2025, 10,000 megawatts of renewables will be installed in Texas, and this goal was achieved 15 years early in 2010 (Clean Energy Authority, 2018; Long, 2013).

The potential for solar power in West Texas is much larger than the amount being utilized. There is the capacity for 154,000 megawatts (or 294 kilowatt hours) of urban utility-scale PV and 20 million megawatts (or 38,000 kilowatt hours) of rural utility-scale PV in the whole state of Texas (Texas Solar Power Association, 2017). However, only 1,874 megawatts overall have been installed and only 0.62% of the state's electricity comes from solar (SEIA, 2018b; Texas Solar Power Association, 2017). Given this data, solar power could technically cover all Texas electricity needs and more, even if the population of Texas doubles between 2017 and 2050 as predicted (Bridging Barriers, 2018). The Solar Global Horizontal Irradiance (GHI), an indicator of solar energy exposure, in West Texas is some of the strongest in the country along with the rest of the southwestern United States, as shown in Figure 5.2 (NREL, 2011b). Solar Global Horizontal Irradiance is best for indicating suitability of solar photovoltaic suitability, as it is the combination of Direct Normal Irradiance (DNI), Diffuse Horizontal Irradiance (DHI), and ground-reflected radiation, which account for temperature, elevation, cloud cover, and humidity (NREL, 2011b). Thus, there is authentic capacity for utility-scale solar plants on University Lands where other means of energy production are not viable or are no longer viable.

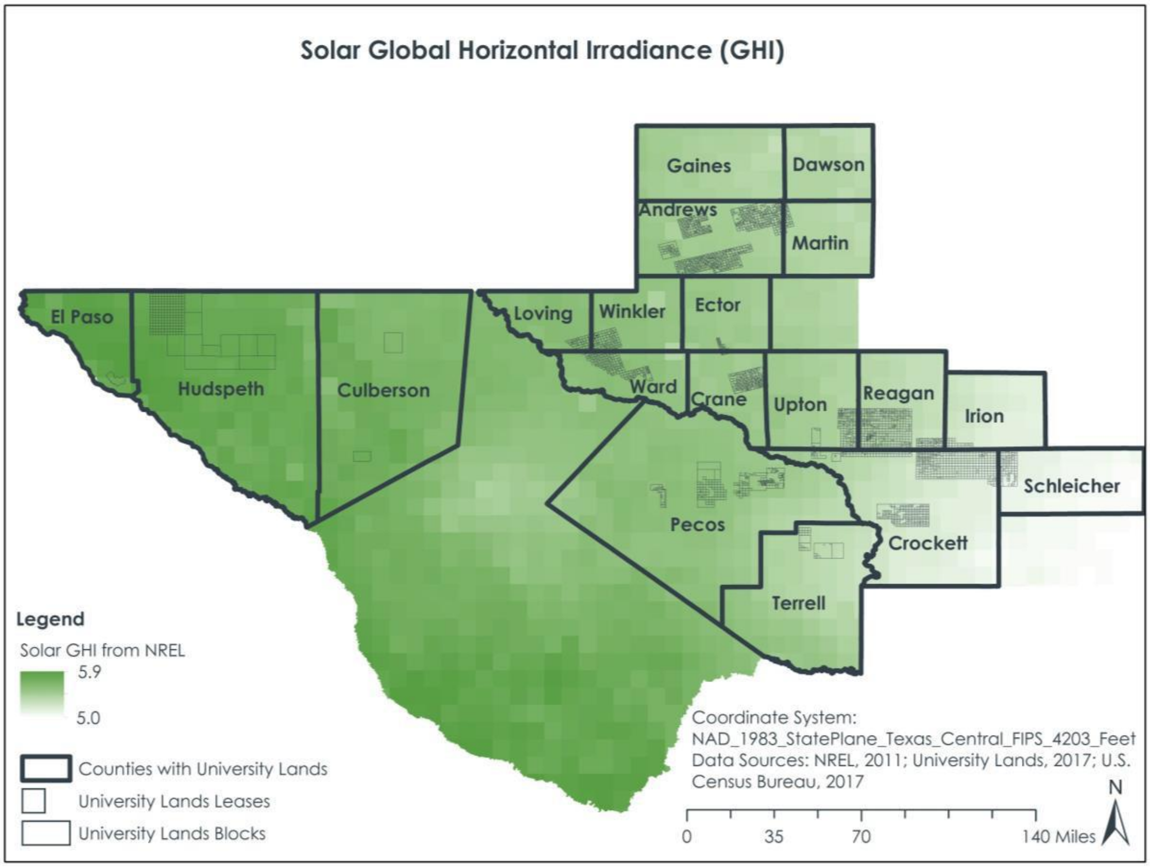


Figure 5.2 (Veazey) Solar global horizontal irradiance, a measure of solar energy.

There is potential for using lands that are contaminated by toxins or former industrial use, often called brownfields, for solar PV farms. An estimate from an NREL study says that a 100-megawatt project on Texas contaminated lands would produce 1,927 jobs during construction and 96 permanent jobs for operation (Macknick et al., 2013). EPA's RePowering sites are land parcels identified by the EPA that are either landfills or brownfields of any nature that would be desirable for various renewable energy projects, and some are specifically identified for Solar PV Utility (EPA, 2015). Go Solar Texas (2016) identified brownfield sites with potential for solar development in Andrews, Crane, Ector, Gaines, Howard, Martin, Midland, Pecos, Reeves, Upton, and Ward counties in

West Texas. The environmental mission of a renewable energy plan would be furthered by repurposing land that has no other value over developing greenfield sites.

CURRENTLY ON UNIVERSITY LANDS

In November 2017, there were already two developers with contracts and three more developers interested in solar farms on University Lands (Mendez, 2017b). These plans have finally come together after solar companies have discussed leasing University Lands since 2015, when University Lands teamed up with UT's Energy Institute to start to develop plans to bring solar there (Mendez, 2017b). Fred Beach of Energy Institute believes in the University Lands' ability to profit from opening land leases to solar and wind companies (Mendez, 2017b). Alyssa Ray, associate director of University Lands, said of solar: "It's becoming more cost competitive with natural gas" and efficiency is improving (Mendez, 2017b). "Ray said about 10,000 acres of land in the Upton, Pecos, Culberson, El Paso and Hudspeth counties will be allocated for five potential solar farming projects" (Mendez, 2017b). The contracts will involve Calpine Corp. from Houston, Recurrent Energy Development Holdings from California, and Hecate Energy from Tennessee, and they will be for about 40 years (Handy, 2017; Mendez, 2017b). There are few other public details for now.

ENVIRONMENTAL IMPACTS

The criteria Mark Reid and I are investigating in the University Lands research project include emissions from each energy source--solar, wind, natural gas with carbon capture and storage, and nuclear. For solar power, almost all of the emissions associated with solar power generation come from the upstream phase (Rhodes, 2017). This is largely because silicon PV manufacturing is energy intensive (World Energy Council, 2016). Due to the toxic materials content of solar panels, they need to be disposed of carefully (World Energy Council, 2016). Recycling solar panels could cost up to $400 per metric ton (World Energy Council, 2016). Recycling is not common in most places but some countries make incentives or legislation to encourage it. Germany has a law requiring manufacturers to take back and recycle the panels within Germany at the end of the lifecycle (World Energy Council, 2016). It is likely that the solar panel technology will continue to advance, and the tradeoff between fossil fuels environmental damage is worth it, as explored later in the chapter.

POTENTIAL FUTURE TRENDS

EPA's Re-Powering is an initiative that identifies existing contaminated lands, landfills, and mining sites and provides resources to help communities create renewable energy production on them (EPA, 2017b). These sites have been implemented in many states including Texas, California, and Arizona (EPA, 2017b). After site identification, an environmental assessment is conducted, a cleanup plan is created, and then cleanup occurs (EPA, 2016d). Post cleanup, "some sites may require monitoring and institutional controls (ICs) to ensure protection of human health and the environment" (EPA, 2016d). Then, renewable energy analysis, design, and construction is done (EPA, 2016d). One example of a contaminated site in San Antonio since 2009 features a landfill covered with a flexible membrane that has solar PV cells, created by Uni-Solar and owned by Republic Services Inc. (Breslin, 2009). The system was innovative technology at the time, and the landfill site already used biogas released from the landfill in a biogas-to-energy system that was able to stay (Breslin, 2009). This sort of land reuse is sustainable because it saves other land where the renewable energy plant would have otherwise been located and it prevents the major cost of traditional membrane and soil cover and the maintenance costs that come with typical landfill sealing (Breslin, 2009). Even if University Lands does not contain any landfills, they could use similar methods to recover lands contaminated from fossil fuel extraction and industrial uses. Producing solar power on contaminated lands no longer producing might enable University Lands to save the cost of full cleaning with a return to native natural state. They could instead see emissions offsets with renewable energy production.

A prominent event to rattle the growth of the solar energy industry was the tariff on imported solar panels enacted by Trump in early 2018. This will likely slow the adoption of solar energy but will not end it. Even though tariffs on imported solar panels would help limit competition with U.S.-based solar panel manufacturers, they would hurt solar production here overall (Swanson and Plumer, 2018). The tariff began when Suniva and SolarWorld Americas, U.S.-based solar manufacturers, argued foreign competition was hurting their sales (Swanson and Plumer, 2018). The truth is, the costs to the country will outweigh the benefits, because the portion of the U.S. solar industry that consists of solar panel manufacturers is very small; 95 percent of solar panels used in the U.S. are imported (Swanson and Plumer, 2018). The industry as a whole and most others employed by it (including installers, maintenance workers, and manufacturers of other parts of the systems) will be harmed by the tariff (Swanson and Plumer, 2018). The tariff will be 30 percent in 2019 and drop to 15 percent in the fourth year (Swanson and Plumer, 2018). The tariff will cause costs to rise, and a GTM Research analysis found that although solar installation growth will continue to 2022, the tariff would likely result in "11 percent fewer panels installed" (Swanson and Plumer, 2018). Nationally, about 23,000 solar jobs in the U.S. are expected to be lost in 2018 because of the tariff (Mock, 2018). In Texas, predictions say up to 6,300 of the state's over 9,000 solar industry jobs could be lost (Druzin, 2017). These would be accompanied by suffering a loss of "hundreds of millions of dollars in investments" (Druzin, 2017). Predictions say the tariff will impact large utility-scale solar PV projects the most, adding one to two dollars per megawatt hour to these projects' cost of electricity (Rhodes, 2018). Tom Matzzie of CleanChoice Energy said that areas with growth in utility-scale solar like Texas and the southeastern and southern U.S. will be harmed the most, because panels are a larger portion of the overall costs for these projects, and cheaper foreign panels have helped drive the growth of utility-scale solar in recent years (Lavelle, 2018). Without a doubt the tariff introduces new challenges.

Solar PV installer is the fastest growing job right now, expected to grow by 110 percent by from 2016 to 2026, according to the Bureau of Labor Statistics (2018a). By comparison, the average growth rate for all occupations is 7 percent (Bureau of Labor Statistics, 2018a). These statistics have even been updated since the tariff announcements, and this could mean promising job opportunities for people with no more education than a high school diploma (Bureau of Labor Statistics, 2018a).

Lastly, once uncertainty about grid storage is no longer a hindrance, solar power will likely grow rapidly. Advancement in grid storage and batteries would make both solar and wind more viable mainstream forms of energy because supply needs to be able to meet demand when demand occurs, not just when the wind is blowing or the sun is shining (Krancer, 2017). Of course, Texas is the only state in the nation with its own grid, without federal oversight, and this offers unique opportunities and challenges (Handy, 2018). Projects around the country have recently tested out storage systems (Krancer, 2017).

WIND ENERGY

Wind energy is created via wind turbines, and a utility-scale wind plant or "wind farm" includes many turbines, usually in arrays of 30 to 150 units, totaling more than 100 kilowatts connected to the utility grid (American Wind Energy Association, 2018; Wilburn, 2011, p. 3). Each turbine reaches around 100 feet above ground and has two or three blades making up a rotor (NREL, 2018). When the wind blows, the rotor spins similar to a propeller and energy is created and transmitted (NREL, 2018). The various components of the tower, rotor, and machinery of a turbine are made from mostly steel but also fiberglass, copper, concrete and other materials. (Wilburn, 2011, p. 3). At least half of the wind turbine structure parts installed in the U.S. are manufactured in the country, and this proportion has been increasing since 2005 (Wilburn, 2011, p. 3).

Wind is a resource that is plentiful, available in many geographies, and is not at risk of any long-term disruptions (Wilburn, 2011). Compared to solar power, it is less environmentally damaging in the material production phase and at end-of-life recycling of materials. However, usually rural areas are the best fit for wind farms, which makes transportation and transmission complex, but also means that University Lands could accommodate wind farms (Wilburn, 2011). Compared to solar, wind uses more land, but wind production can be paired well with farming and ranching, which is happening on University Lands currently (Wilburn, 201; NextEra Energy Resources, n.d.). In the short-term, wind supply is highly variable and unpredictable, and many people complain of noise and visual nuisances with turbines (Wilburn, 2011). Wind energy is more common than solar in Texas and the U.S. as a whole, and while solar is rapidly growing, wind energy continues to steadily grow.

NATIONWIDE TRENDS

In 2017, the net wind production in the U.S. was over 254 million megawatt hours, which is 6.3 percent of total electricity generation, up a fraction of a percent from 2016 (EIA, 2017a; EIA, 2018; Handy, 2018). Like solar, the wind industry has been rapidly growing. Overall, “27 percent of all energy capacity additions in 2016” came from wind

(U.S. Department of Energy, 2017). More than 100,000 jobs related to wind--in siting, manufacturing, project development, transportation and more—existed in 2016 (U.S. Department of Energy, 2017).

Many federal tax incentives for renewable energy like solar also cover wind energy. This includes the Production Tax Credit and the Investment Tax Credit, which are phasing down but will extend through 2019 (American Wind Energy Association, n.d.). The new 2018 federal tax plan has the same potential for wind as it does for solar to lessen the advantage of tax credits investors receive (Sweet, 2018). For solar as well as wind, power purchase agreements (PPAs) are an important policy making renewable energy feasible; they are used to guarantee a set electricity rate with utilities or municipalities for a determined time (Druzin, 2017)

There is capacity for 33 million gigawatt hours onshore and 17 million gigawatt hours offshore of wind energy in the U.S., which is more than 10 times current national electricity consumption (Madsen and Sargent, 2016). The U.S. Department of Energy predicts the nation's actual capacity for wind power will increase by 9 percent and 8 percent in 2018 and 2019, respectively (Handy, 2018). The predictions for national growth of wind in the near-term are more steady and clear without the same sort of effect the new tariff has on the solar industry.

IN THE WEST TEXAS REGION

Texas is the state with the highest installed wind power capacity, holding about a fourth of the nation's overall, which was over 20 gigawatts in 2016 and equaled to more than 67 million net megawatt hours produced in the state in 2017 (U.S. Department of Energy, 2017; Handy, 2018; EIA, 2018). Wind is the second-biggest power source in Texas currently, behind natural gas and ahead of coal (Handy, 2018). This translates to 22,000 to

23,000 wind jobs in Texas in 2016 (Ivanova, 2017). Thus, the industry is significantly larger than the solar industry, and growing larger, while solar has room to start to grow more quickly now.

Just as is allowed for solar power, Texas allows companies to eliminate the franchise tax if they only produce, sell, or install wind products, and a corporation can deduct the cost of a wind device from its franchise tax (DSIRE, 2015a; DSIRE, 2015b). Since 2005, a Texas state policy called Competitive Renewable Energy Zones, which extends transmission lines to places where wind might be developed--and solar now, too--has helped grow wind power production especially in West Texas (Handy, 2018). An additional state-level effort that has made a difference is the Renewable Portfolio Standard, which applies to wind as well as solar energy (Long, 2013).

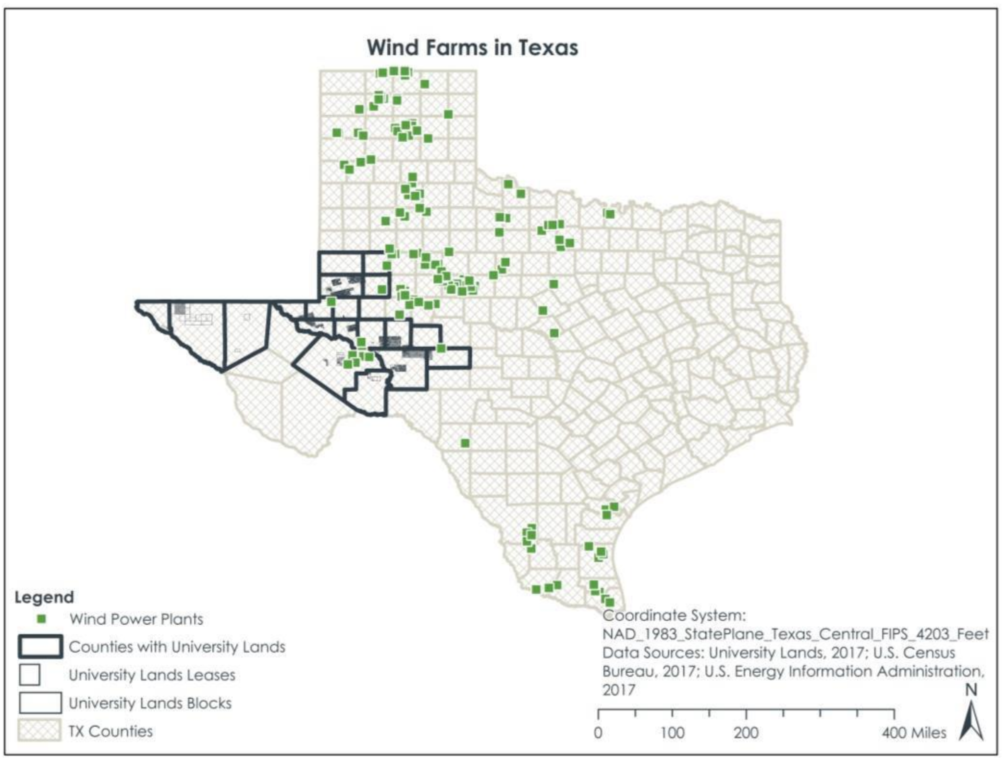


Figure 5.3 (Veazey) Existing Wind Farms in Texas.

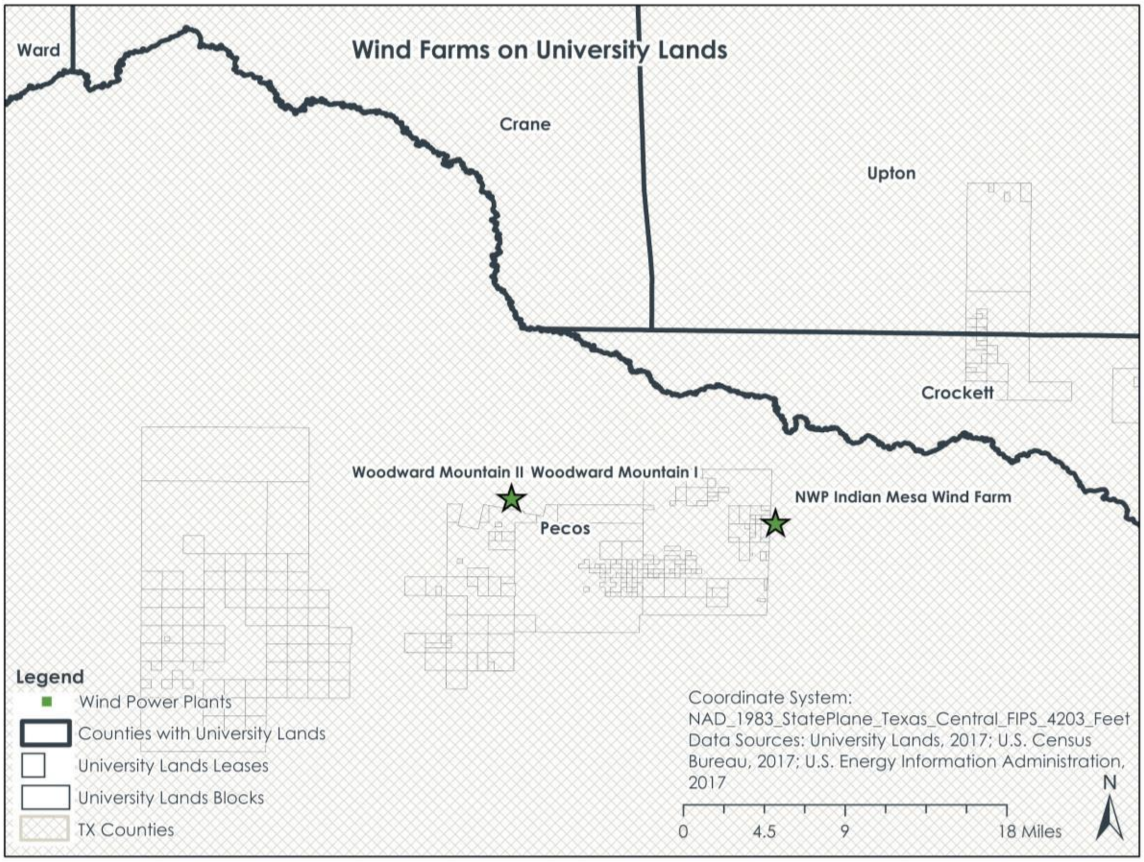


Figure 5.4 (Veazey)
Wind Farms on
University Lands,
zoomed in.

As high as current production and capacity in wind energy is in Texas, the technical potential is even higher. Potential for wind power produced in Texas onshore and offshore is double the power needed for annual U.S. electricity use, says NREL (Lopez et al., 2012). There are 144 wind farms in Texas, many more than solar farms, and 30 are in the region of University Lands counties, as shown in Figure 5.3 (EIA, 2017b). The two wind farms on University Lands are shown in Figure 5.4. This is compared to 159 natural gas plants and 2 nuclear plants in the state (EIA, 2017b). One can see from Figure 5.5 that wind speed and quantity of wind as a resource in Texas is high relative to many other regions in the country (NREL, 2011)

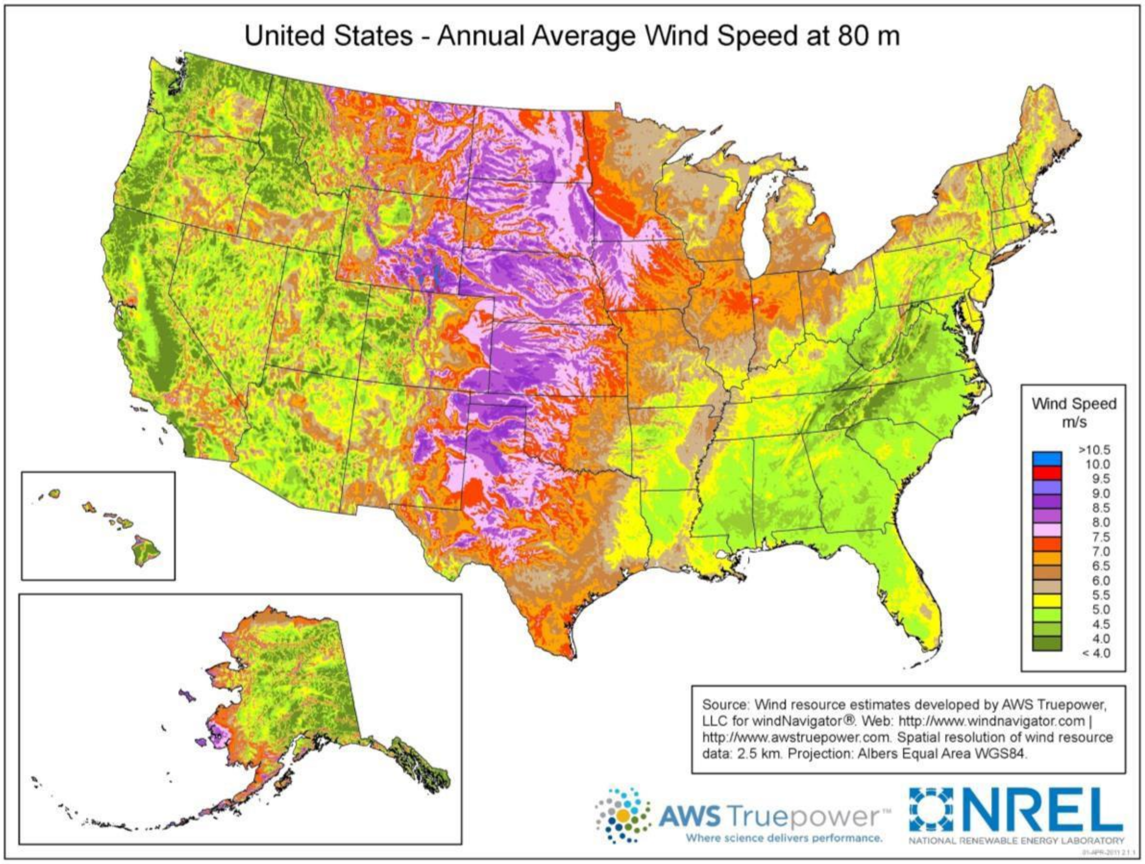


Figure 5.5
(NREL, 2011)
Wind speed.

Currently on University Lands

There are just a few wind farms located on University Lands (University Lands, 2017a). Woodward Mountain Wind Ranch and Indian Mesa Wind Farm both opened in 2001 and are currently owned and operated by NextEra Energy Resources (Long, 2013; NextEra Energy Resources, n.d.). Woodward Mountain Wind Ranch is a 160-megawatt farm with 242 turbines in Upton and Pecos Counties powering over 70,000 homes (Cielo Wind Power, 2017; Long, 2013; NextEra Energy Resources, n.d.). The plant, installed by Cielo Wind Power in agreement with TXU Energy utility, employs a staff of nine (NextEra Energy Resources, n.d.; Cielo Wind Power, 2017). Fifty landowners on its over 9,000 acres use land not used directly by turbines largely for agriculture (Cielo Wind Power, 2017; NextEra Energy Resources, n.d.) Indian Mesa Wind Farm, nearby in Pecos County, is smaller at 82.5 megawatts with 124 turbines and powers over 20,000 homes (Long, 2013; The Wind Power, 2017). National Wind Power, Orion Energy LLC, and Mortenson developed and installed the project in 2001(The Wind Power, 2017). The farm was still hiring staff in December 2017 (Glassdoor, 2017).

The biggest issue is in transmission lines capacity, as it is difficult to transport wind from sparsely-populated West Texas to urbanized, highly-populated East Texas, but of course the Competitive Renewable Energy Zones policy in Texas reduces some of that challenge (Long, 2013; Handy, 2018).

Environmental Impacts

Wind power gets a lot of criticism for reports of turbines killing bats and birds, and this is a legitimate concern. One study found bat fatalities are relatively low in the southwest region that includes West Texas, with a mean of 1.29 bats killed per megawatt hour in the 28 post-construction sites studies, and this was despite the general lack of low bat activity compared to other regions in the pre-construction detector studies (Hein et al., 2013). Some suggestions to reduce bat and bird deaths include methods for siting and construction turbines, adjusting turbine structure, and changing turbine functionality. Birds might be less disturbed if construction of wind plants is done outside of their breeding seasons (Dai et al., 2015). In terms of machinery, some studies suggest that larger blades moving at lower speeds and pattern-painted blades to make them more visible might reduce bird fatality (Dai et al., 2015). Impacts of placing bright lighting on blades and whether this practice warns or attracts bats and birds varies (Dai et al., 2015). During wind energy production, if the rotor speed itself is reduced but the cut-in speed (i.e. the wind speed at which turbines "turn on" and create power for the grid) is increased, bat fatalities can go down (Arnett et al., 2013). There is a concern to study the Brazilian free-tailed bat more closely as there is limited information, and they populate Texas and they fly at higher speeds than typical animals (Hein et al., 2013; Arnett et al., 2013). Unnecessary killing of animals and destruction of biodiversity are unfortunate consequences of wind power generation that should be studied and minimized.

Disposing of used wind turbines is a smaller issue than disposing of solar panels. A U.S. Geological Survey study assumes that materials used in turbines, aluminum, cast iron, concrete, copper, electronics, and steel, will be recycled at a 90 percent rate 25 years after they are built in the near future (Wilburn, 2011, p. 13) Only minimal amounts of recycled materials in new wind turbines are currently used (Wilburn, 2011). Repowering (not to be confused with EPA's brownfield sites) is a concept in which turbines are replaced with powerful turbines or pieces of turbines so that more megawatts can be produced with no increase in impact (Subramanian, 2017). In addition to minimizing risks to flying animals, wind energy technology researchers should focus on recycling and reuse methods and policies to lessen the environmental footprint of wind power even further.

POTENTIAL FUTURE TRENDS

Like solar plants, wind farms have potential to be established at brownfield sites and will benefit from increased development in grid connection and battery storage. A very recent transaction in Texas strengthened the link between wind plants and battery storage when Sempra Energy, a leader in electric vehicles, bought the Oncor Electric Delivery utility (Chediak and Collins, 2018). Wind could help power electric vehicles. Oncor cannot buy batteries according to Public Utility Commission rules, but if that hurdle is passed, wind could see even more growth in the region (Chediak and Collins, 2018). Jobs are growing rapidly in wind even as it has been a common renewable source for years. Wind turbine technician is the second-fastest growing job in the U.S. right behind solar PV installer, and it is expected to grow by 96 percent from 2016 to 2026 (Bureau of Labor Statistics, 2018b). This role also does not require a college degree, only some post- secondary education and still offers an average salary of $52,260 per year (Bureau of Labor Statistics, 2018b). Employment rates in West Texas will without a doubt benefit from these trends.

Changing technology offers huge potential for reducing impact and increasing efficiency of wind plants. Over the years, wind turbines have gotten taller and come with rotors that are gradually becoming larger as power output increases and offshore wind is becoming gradually more viable (Madsen and Sargent, 2016, p. 35). Further, designers in Spain are experimenting with making "bladeless" turbines, which could drastically reduce environmental impacts and sound nuisance (Frangoul, 2017). If environmental impacts were reduced, coupled with better storage and transmission, locating turbines would be less location-sensitive and the energy source could see major advancement.

METHODOLOGY OF THE RESEARCH PROJECT

The first couple of months of our research project consisted of gathering preliminary data. This included data from University Lands, about carbon capture and storage, about wind and solar in West Texas, and from research organizations and other resources from within UT. It also involved speaking to representatives at University Lands some, getting in contact with oil and gas industry employees, speaking to representatives of the Bureau of Economic Geology, creating a project timeline, starting preliminary maps and suitability maps and downloading various other GIS files. The direction of the project changed from a more narrowed focus, with a recommended specific project on a particular plot of land in a specific county to a broader analysis of various methods based on comparable criteria. We do not have the needed information to choose a site, plus the method we chose is less controversial and more realistic for the parameters we were given, and it might be more useful at present and for other UT groups to add onto in the near future.

The goal of the research project is to identify methods to reduce, offset, and/or sequester greenhouse gas emissions in ways that are currently compatible with uses of University Lands. This means ways that are economically feasible and create no loss in revenue. Because of how University Lands leases lands to oil and gas producers and receives immediate returns, and because of how PUF is set up (as fossil fuel production is a substantial part of the state economy), it is unrealistic to replace much of the current uses immediately with wind and solar or other renewables, that require a longer time period to see returns on investment.

By the end of the first semester of the project, our research team settled on a report outline comparing methods of reducing and offsetting GHGs that are comparable across

“Economic,” “Environmental,” and “Political Feasibility” criteria. Solar energy, wind energy, and carbon capture and storage had piqued our interest since the very start of the project. After extensive literature review of work from the Energy Institute at UT, we decided to make solar energy, wind energy, and natural gas with carbon capture and storage (CCS) plants some of the main methods. Because Energy Institute also had parallel data about nuclear energy plants and nuclear is low-emissions, we decided to include it as well.

Many of our study criteria are based on an Energy Institute study about costs of electricity that considered ten scenarios: “a conventional scenario that disregards the costs from environmental externalities, a scenario that includes environmental externalities, a scenario that includes environmental externalities and considers restrictions on where one might be able to site specific technologies, a conventional scenario that disregards the costs from environmental externalities but includes restrictions on siting, scenarios for high and low natural gas prices, scenarios for high and low CO2 prices, a scenario with low solar capital costs, and a scenario using the location’s maximum available onshore wind capacity factor” (Rhodes et al., 2016, p. 1-2). All costs are in 2015 USD and the LCOE “assumes the marginal addition of one power plant” (Rhodes et al., 2016, p. 4). The natural gas with CCS option is a natural gas combined cycle technology plant with CCS.

We decided to include nuclear energy among our main methods because of the availability of data about nuclear energy from the Energy Institute. However, there are many problems with nuclear. The biggest issues are dealing with waste disposal and the threat of accidents. Two of the most notorious nuclear disasters were Chernobyl, Ukraine in 1986 and Fukushima, Japan in 2011 (Greenpeace, 2016). Although nuclear has positive environmental benefits in terms of low emissions, it is not renewable in that uranium is needed to supply it and there is not enough uranium on earth to make nuclear our main energy source (Greenpeace, 2016). Nuclear is also an expensive power supply to implement (Greenpeace, 2016). Thus, solar and wind energy are better low-emissions sources.

It is important to note why this project needs to address emissions from oil and gas production. As noted in Chapter 1, methane and other sources could soon be regulated, but the fight is long-term, and the possible federal regulations would not be as stringent as those in states like California and Colorado. Existing air regulations do not cover oil and gas production because of the pollutants and source characterization. The Clean Air Act sets NAAQS (National Ambient Air Quality Standards) for the criteria pollutants carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide and, past that, regulates toxic emissions from major sources (EPA, 2016e). A major source is "a stationary source or group of stationary sources that emit or have the potential to emit 10 tons per year or more of a hazardous air pollutant or 25 tons per year or more of a combination of hazardous air pollutants" (EPA, 2017d). The Clean Air Act also covers some "area sources," in controlling toxic air pollutants, "those pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects" (EPA, 2016c). The review of stationary sources' emissions of GHGs is limited, anyway. The court's decision in Massachusetts v. EPA determined that the EPA can regulate GHGs from mobile sources (Plater et al., 2010, p. 482). Then, in Utility Air Regulatory Group v. EPA in 2014, it was decided that the Massachusetts v. EPA decision does not apply to stationary sources, but if the Prevention of Significant Deterioration (PSD) is triggered "anyways" by another pollutant not attaining, then the EPA will also review GHGs (Supreme Court of the United States, 2014). Plus, in Texas, oil and gas drilling do not report to the Toxic Release Inventory (TRI) (Kidd, 2017). The TRI was established in 1986 as a part of the Emergency Planning and Community Right-to-Know Act (EPCRA) (Kidd, 2017). It created the EPA database of releases and disposal of more than 69 toxic chemicals from thousands of industrial facilities in the U.S. (Kidd, 2017). This database is public and includes oil-powered and coal-powered plants in Texas, and it has been proposed to include natural gas plants, but production sources are not included although studies have found that toxic chemicals are released there (Kidd, 2017; Earthworks, 2017).

Fossil fuel production is linked to public health problems. A Lawrence Berkeley Lab study found that from 2007-2015, Americans saved $88 billion in environmental and health costs thanks to solar and wind energy production (Roberts, 2017). These costs consist of reducing sulfur dioxide by 1 million tons, nitrous oxide by 0.6 million tons, and particulate matter 2.5 by 0.05 million tons (Roberts, 2017). This likely prevented around 7,000 premature deaths and $56 billion spent in public health impacts. The estimate of climate costs from CO2 emissions avoided is about $32 billion (Roberts, 2017). The continuation of renewable energy replacing some of the oil and gas production and use would reduce harmful emissions here in Texas and across the nation. The purpose of the University Lands project is not to evaluate public health concerns related to oil and gas production, and University Lands are in relatively sparsely populated areas. However, it is imperative to explore how limited emissions regulations are for not only climate-change causing GHGs but also toxic pollutants related to production and that industry, universities, landowners, and other stakeholders have vital roles to play.

Several methods with which to offset, reduce, or sequester GHG emissions were considered from the start of the project, but since data equivalent to the Energy Institute data for the main methods did not exist, we chose to place some of those in our “alternatives” methods section. Some methods in this section are not meant to be categorized as subpar vis-à-vis the main methods--like methane seals, for example. They are only placed there due to data limitations and our attempt to reasonably score and rank methods and to make decisions somewhat quantitatively about and somewhat qualitative data. Other than methane reductions (including seals for pneumatic controllers and other equipment updates), alternative opportunities include algae ponds, biofuel irrigated with brine, geothermal energy, and reducing drilling. Biofuel generation from algae is the conversion of lipids and carbohydrates, produced via photosynthesis, into hydrocarbon in ponds onsite with oil and gas production (Behrendt et al., 2018). My colleague Mark Reid completed a research finding that this method is not viable in the near future on University Lands as either large scale carbon capture or as a profit-making fuel source. While companies such as ExxonMobil have invested in the use of algae as biofuels, there remain challenges that make it unrealistic and uneconomical to produce algae hydrocarbons at industrial scale (Futurism, 2017; Carey, 2009). Another biofuel option explored was growing typical biofuel irrigated with brine wastewater from fossil fuel production; however, my research and discussions with Dr. Susan Hovorka at the Bureau of Economic Geology determined it is not among the most cost-effective or environmentally-friendly methods. Brine has 50,000 to 150,000 parts per million total dissolved solids (TDS), but crops can only tolerate around 1,200 ppm to as much as 10,000 ppm (Colorado Water Resources Institute, 2006). The water would have to be treated extensively, which would be very costly (Colorado Water Resources Institute, 2006). There are better available low-quality water sources that would be easier and less costly to treat to meet the required quality for irrigation (Mantell, 2011). Some areas, such as the Barnett Shale, have thorough salt water disposal well systems already in place, making it much more convenient and much less expensive than irrigation reuse (Mantell, 2011). The study of geothermal energy found that not much of the West Texas region is favorable for deep enhanced geothermal systems (Madsen and Sargent, 2016, p. 24). Our research team chose to include reducing oil and gas drilling as an option, as it is an obvious choice when considering how to reduce emissions, however the literature review in the Center for Sustainable Development (CSD) University Lands report will cover how it is not a viable method at present as it is economically incompatible with current uses.

ENVIRONMENTAL CRITERIA

The report with include at least five environmental criteria and seven economic criteria. The environmental criteria include "Lifetime of Energy Source," "Acreage per Megawatt Capacity," and "Levelized Carbon Dioxide Emissions in Kilograms of Carbon Dioxide per Megawatt Produced." We have begun to develop "Carbon Dioxide Equivalent Emissions Avoided per [Time Unit]" and a "Water Use" criterion. Both wind and solar energy power generating facilities have similar lifetimes, about 20 to 25 years (Dykes et al., 2017, Energy Institute, 2017b, Feldman and Lowder, 2014). NREL typically base capital structure and any pro-forma financial model on the assumption of a 20-year lifetime and Energy Institute chose 25 years for the automatic power plant lifetime for each plant type (Feldman and Lowder, 2014; Energy Institute, 2017b). Nuclear and natural gas with CCS both have longer lifetimes typically, averaging 35 years and 50 years, respectively (Energy Institute, 2017b). Solar is viewed as better than wind in acreage per megawatt capacity at 8.9 acres, which is close to the 6.8 acres needed for natural gas with CCS and the 11.7 acres needed for nuclear (Ong et al., 2013; Strata 2017, EIA, 2018). Wind farms need 85.24 acres per megawatt capacity as a legal boundary but only 0.74 acres per megawatt as operational impacted land, so it can be difficult to compare (U.S. DOE, 2015). Much of the land use in the legal boundary of a wind farm is dedicated to farming and grazing (U.S. DOE, 2015). The Energy Institute studies delved into life cycle emissions, which include all phases: "1) upstream, 2) on-going, non-combustion, 3) power generation, 4) carbon sequestration, 5) fugitive methane emissions and 6) downstream" (Rhodes, 2017). Wind does better than solar in levelized carbon dioxide emissions, at 14 kilograms (kg) per megawatt produced versus 41 kg for solar (Rhodes, 2017). The emissions are much higher for natural gas with CCS at 204 kg, but the lowest of all options analyzed was for nuclear at 12 kg (Rhodes, 2017). See Figure 5.6 and Figure 5.7 for where emissions come from for wind and solar. Most emissions for each come from the upstream phase. In fact, solar photovoltaic and concentrated solar power are the energy sources with the highest life-cycle upstream CO2 emissions (Rhodes et al., 2016, p. 9). Wind and solar of course have no combustion and therefore emit no sulfur dioxide, nitrous oxides, particulate matter, combustion carbon dioxide or the methane equivalent, as they are clean energy (Rhodes et al., 2016, p. 9). Wind's ongoing, non-combustion emissions come from operations and maintenance (Rhodes, 2017).

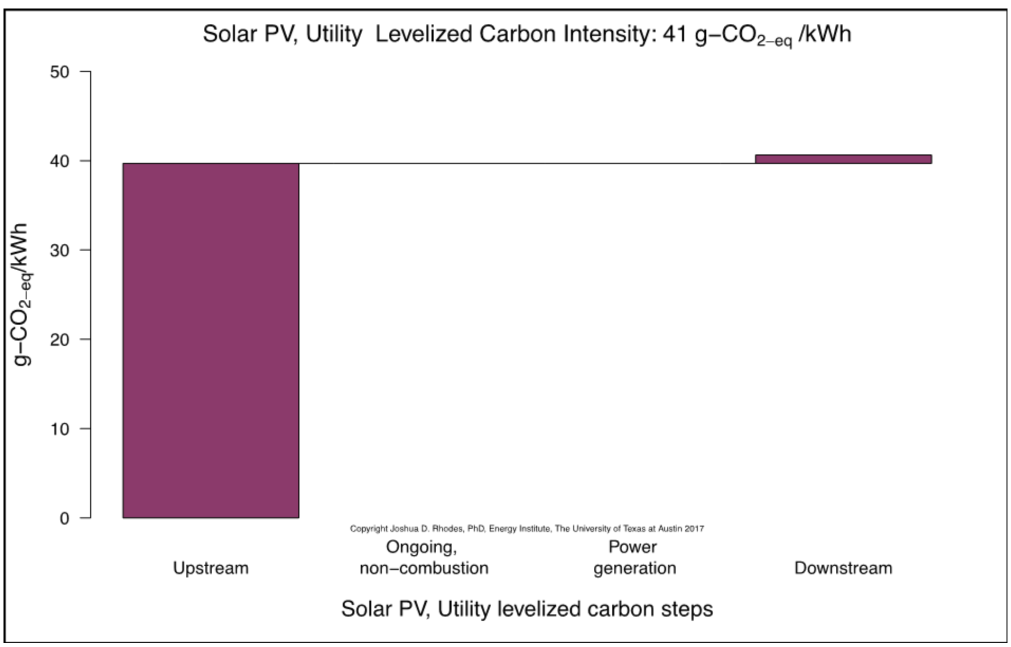


Figure 5.6 (Rhodes, 2017)
Solar levelized carbon
emissions.

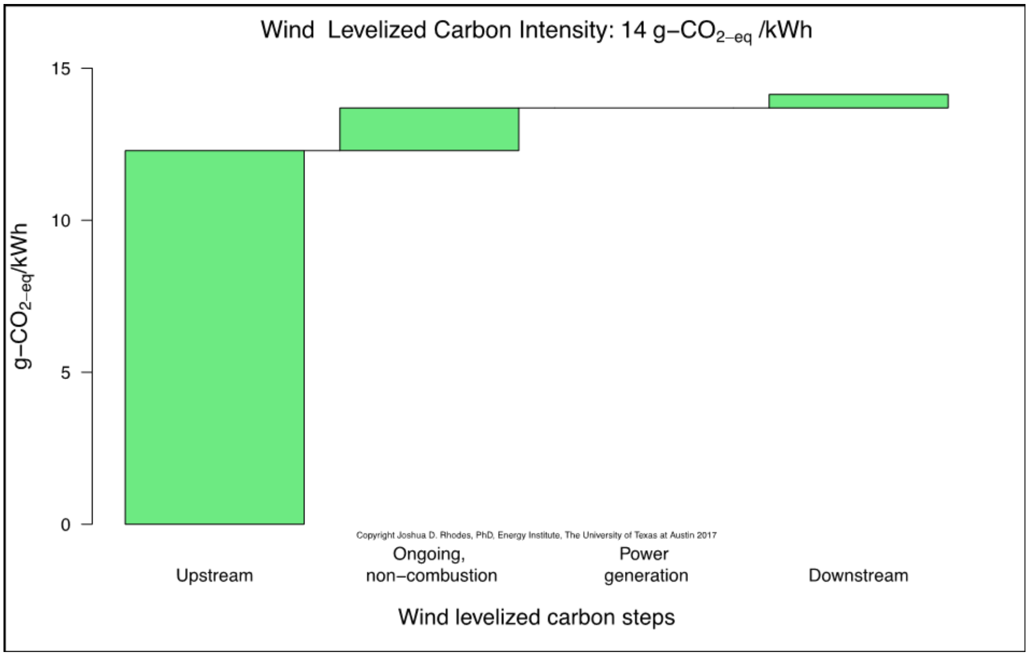


Figure 5.7 (Rhodes, 2017)
Wind levelized carbon
emissions.

ECONOMIC CRITERIA

Our CSD University Lands report will include the following seven economic criteria:

- Cost to Create or Implement per Acre
- Cost to Create or Implement per Megawatt
- Overall Net Profit in Life Cycle
- Percentage of University Lands Counties in which this Option is Cheapest when Considering Carbon Dioxide Externalities
- Percentage of University Lands Counties in which this Option is Cheapest when Not Considering Carbon Dioxide Externalities
- Average Cost of this Option in University Lands Counties when Considering Carbon Dioxide Externalities

- Average Cost of this Option in University Lands Counties when Not Considering Carbon Dioxide Externalities

Solar does best in creation cost per megawatt. Our studies found that the cost to create per megawatt is cheapest for solar at approximately $1.15 million, followed by wind at approximately $1.81 million, according to the Energy Institute (based on NREL data) (Energy Institute, 2017b). The next most expensive among our main methods was natural gas combined cycle with CCS, which is more expensive than one without CCS, at approximately $3.72 million (Energy Institute, 2017b; Stevens, 2017). Based on megawatt production by acre, the nuclear energy creation cost per megawatt is approximately $16 million (Stevens, 2017). The trend is similar for average cost of plants in University Lands counties when considering carbon dioxide externalities, although the order of solar and wind are switched. Considering a price on carbon dioxide that is pre-determined on the LCOE calculator at $63.93 per ton, $47.40 per ton of upstream carbon dioxide, and $78.26 per ton of downstream carbon dioxide, wind is the cheapest power plant option in the 19 counties containing University Lands at an average of $80.90 per megawatt hour (MWh), followed by solar at $82.35 per MWh, then natural gas combined cycle (NGCC) with CCS at $135.23 per MWh, and lastly, nuclear at $141.76 per MWh (Energy Institute, 2017b). The 19 counties' costs for wind have a range from $62.48 to $130.59 per MWh, while solar has a narrower range of $76.19 to $99.07 per MWh (Energy Institute, 2017b). Again, using the LCOE calculator but changing all the costs for CO2 externalities to $0, solar becomes cheaper than wind at $80.02 per MWh, followed by wind at $80.46 per MWh, followed by NGCC with CCS at $121.31 per MWh, followed by nuclear at $140.92 per MWh (Energy Institute, 2017b). As a result, wind is the cheapest power plant option in 16 of the 19 counties when considering carbon dioxide externalities and is still the cheapest in a regular scenario (not putting a cost on CO2) in two of the 19, Upton and Reagan (Rhodes et al., 2016). Our analysis used Scenario 3 in the report for considering externalities, which includes availability zones and reference case assumptions that are detailed in Tables 1-3 in the report, and Scenario 1 when not (Rhodes et al., 2016). In Scenario 3 considering CO2 externalities, El Paso is the only county for which solar was deemed cheapest and Culberson and Loving are the only counties for which natural gas combined cycle (without CCS) was cheapest (Rhodes et al., 2016). The report's Scenario 1, which does not place a cost on emissions, reveals that natural gas combined cycle, which does not include carbon capture and storage, is the cheapest electricity choice for all counties besides Upton and Reagan (Rhodes et al., 2016).

Using Ragheb's (2017) formula, both wind and solar farms are profitable in a lifetime but wind is many times more profitable. A wind farm with 400 MW capacity in size (this would be equivalent to over 600 wind turbines of 0.6 MW or 200 wind turbines of 2 MW) with the average overnight cost per kW of $1,810.24, fixed Operations & Maintenance costs of $39.19 per kW-year, an average capacity factor of 37%, a price of electricity of 9.9 cents per kW-hour, and a discount rate assumed to be 10%, the net present value of the income stream is approximately $1.122 billion. A smaller wind farm of 85 MW capacity, would have a net present value of the income stream of approximately $236 million. Using the same formula, solar farms of 50 MW capacity and 200 MW capacity, respectively, have a life cycle income net present value of approximately $92 million and approximately $368 million (Ragheb, 2017).

SUITABILITY MAPPING

Using Esri ArcMap Geographic Information Systems software, I conducted suitability analyses of the 19 West Texas counties containing University Lands, first for solar then for wind. Much of the criteria I borrowed came from Noorollahi et al. (2016), Janke (2010), Uyan (2013), Watson and Hudson (2015), and Chen et al. (2014). For example, Noorollahi's (2016) study of solar suitability in Iran includes solar radiation, temperature, elevation, cloud cover, humidity, and number of dusty days. I studied NREL's various layers of solar radiation available and found the solar Global Horizontal Irradiance is the best proxy for solar PV suitability, as it is the combination of Direct Normal Irradiance (DNI), Diffuse Horizontal Irradiance (DHI), and ground-reflected radiation, which account for temperature, elevation, cloud cover, and humidity. All of the literature mentioned prior also uses distance to electric power transmission lines, distance to roads, and distance to residential areas, "villages," or "cities" (Chen et al., 2014; Janke, 2010). Land use criteria varied, and I largely based my decisions on using the NLCD land cover data and ranking choice thereafter on Noorollahi (2016) and Janke (2010). Sanchez-Lozano et al. (2013) constrained urban lands, but I chose not to include urban lands in the constraints but rather to simply deter development within 1.5 miles and prioritize land within 1.5 to 2.5 miles of incorporated places. A more detailed study would look at land use and zoning and prioritize industrial zones and stay away from residential zones. Based on the studies that also contained wind suitability mapping, I used 50-meter estimates of annual average wind resources from NREL (2012). The final maps can be seen in Figures 5.13 and 5.14. The weights for each layer based on my literature review are as follows:

Solar GHI/Wind resources: 42% (see Figure 5.2 and 5.8)

Transmission lines: 21% (Figure 5.9)

Land cover: 17% (Figure 5.10)

"Places" (Cities and towns): 12% (see Figure 5.11)

Roads: 8% (Figure 5.12)

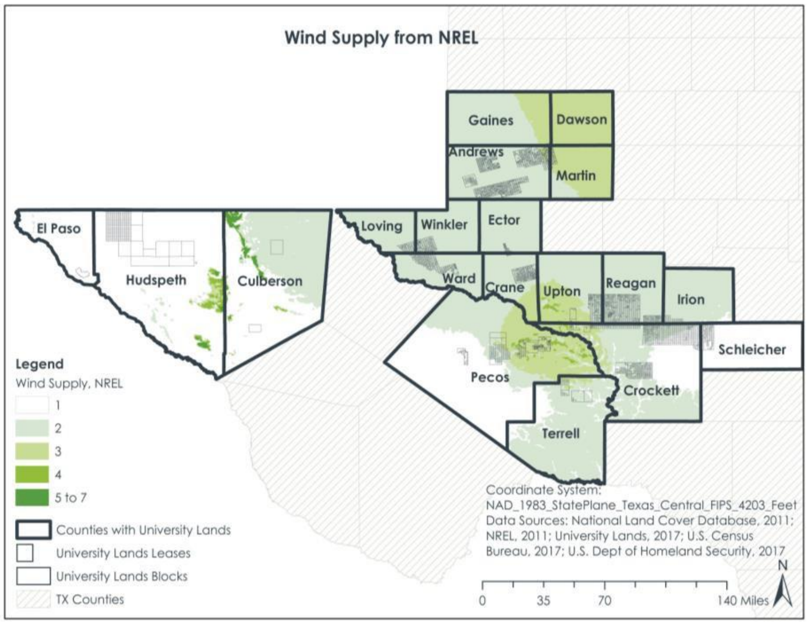


Figure 5.8 (Veazey)
Wind supply.

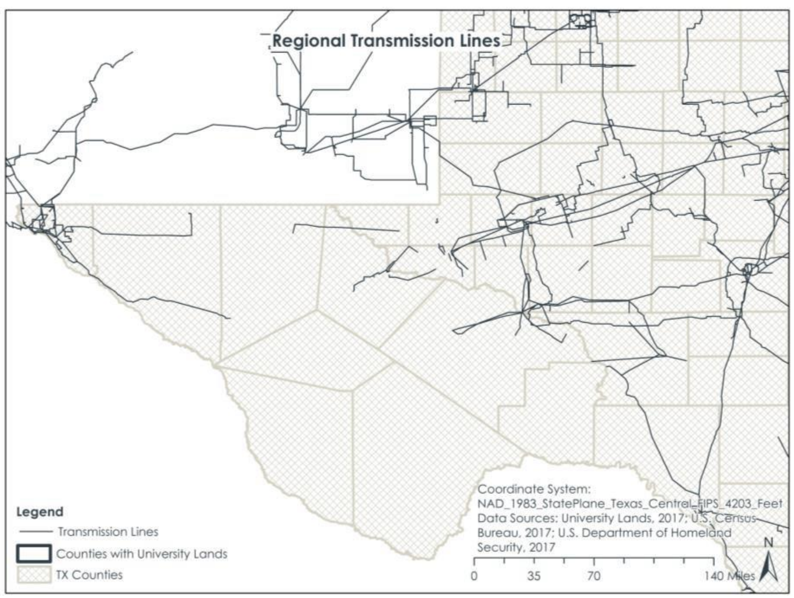


Figure 5.9 (Veazey). Major regional transmission lines.

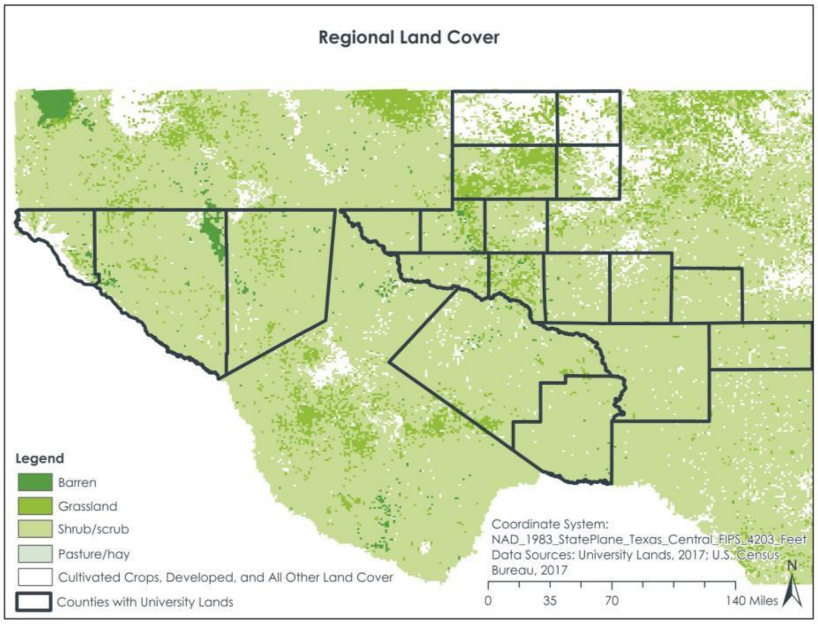


Figure 5.10 (Veazey)
Land cover.

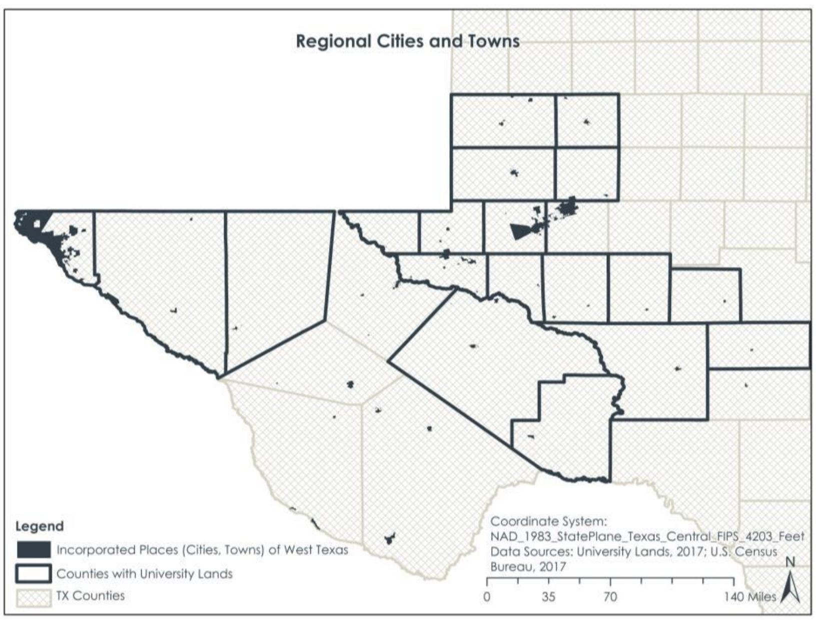


Figure 5.11 (Veazey) Incorporated/census places.

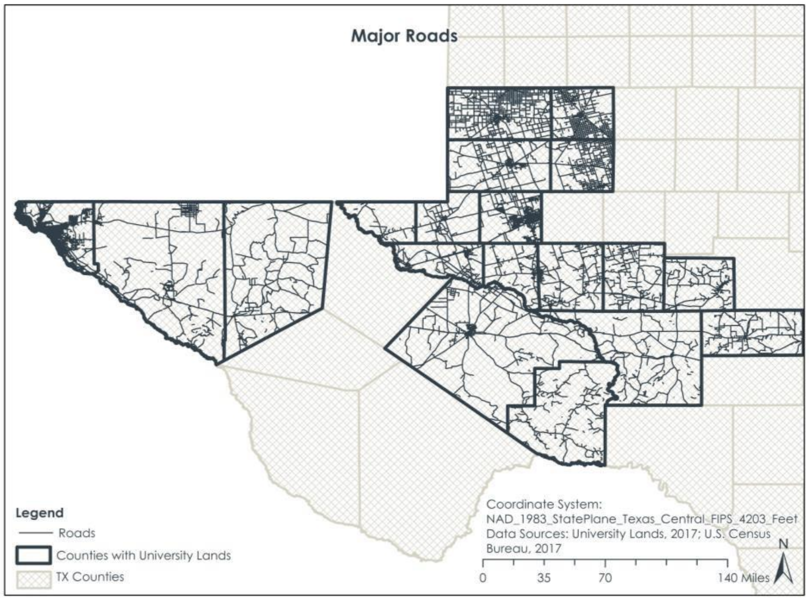


Figure 5.12 (Veazey)
Major roads.

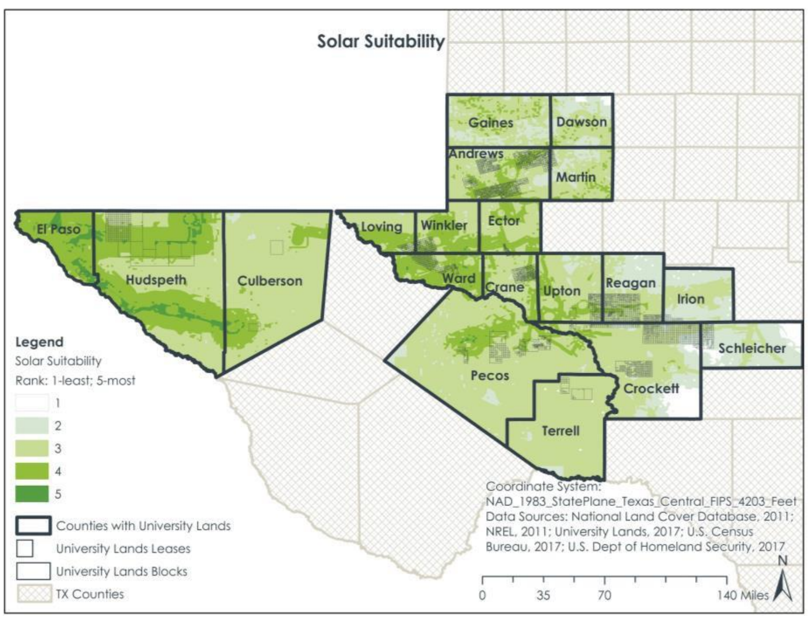


Figure 5.13 (Veazey) Solar suitability analysis.

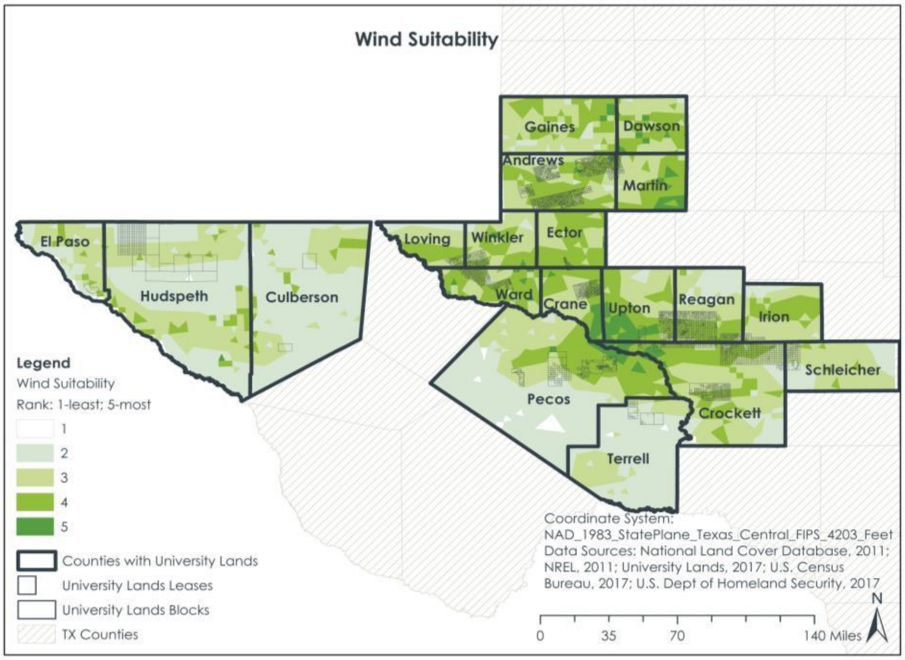


Figure 5.14 (Veazey)
Wind suitability
analysis.

I plan to be careful not to put too much weight in these maps, as West Texas overall is highly suitable for both solar and wind power, and there might be areas ranked "1" that are actually quite suitable for solar or wind. My results do support the Energy Institute findings that Upton and Reagan are the counties where wind is the cheapest, and solar is cheapest in El Paso (Rhodes et al., 2016). Wind farms on University Lands are already in Upton and Pecos Counties and a solar farm is being built in Pecos County (Bubenik, 2018; Long, 2013). My suitability analysis method could be used as a model to redo analyses on a smaller scale or with more data. Additional research for the Green Fee project will include looking into where federally protected lands, bird flight migration patterns, and endangered species overlap with University Lands and what these factors mean for energy production feasibility.

Conclusion

This report was undertaken in order to view the University Lands research project in the context of the timeline of all the work in sustainability and climate action at UT Austin. To do so, it considered current use of University Lands and their role in UT finances, various UT sustainability plans, and how alternative uses of University Lands might fit in with UT sustainability goals. It also reviewed sustainability efforts of other universities and contours of contemporary solar and wind production to discuss how renewable energy fits in in West Texas.

It is essential to explain that the Energy Institute included current tax credits and government subsidies in their cost estimates, making solar energy and wind energy look better than they would without them and fading the true market values of power plants (Rhodes et al., 2016). Additionally, although wind is the cheapest electricity source when there is a price on carbon dioxide for 16 of the 19 counties containing University Lands, natural gas combined cycle is the cheapest source in 17 of the 19 (all but Upton and Reagan) when not considering CO2 externalities. We approach the research project with a sustainability lens, so utilizing regular natural gas combined cycle electricity is not a method to explore. Without CCS, natural gas plants are already very common in Texas and produce around 464 to 674 kilograms in levelized CO2 emissions per MW produced (Rhodes, 2017). Economics factor into our analysis, but methods must first reduce, sequester, or offset emissions to be considered.

On the other hand, lifecycle emissions for oil and natural gas are much higher than those for wind, solar, and nuclear, and are much higher than their own production emissions. However, we cannot focus on oil and gas lifecycle emissions in the report because it is outside of University Lands' scope--they can only control what happens on their land, at production. If we were to look at oil and gas lifetime emissions, there would be much more to offset.

Another caveat to the research project is that we will score the various criteria and then add up the scores to score and rank the main four methods. Of course, the scoring of these select criteria cannot tell the whole story about these types of energy sources. Scoring is inherently subjective, and we cannot ascribe precision where it does not belong. We try to find the most accurate data when we can but are ultimately making claims about qualitative data with subjectivity coming into play. Of course, the Center for Sustainable Development is biased towards sustainability, but we have a cross-disciplinary team with Earth and Energy Resources and an adviser with a background in the oil industry. The original project proposal was written with a drive to truly uphold compatibility with current uses of University Lands.

The potential for wind energy development on University Lands is high, and the potential for solar energy development is present and a bit more uncertain given federal policy and existing trends. Certainly, the potential and profitability of these methods are expected to grow over the next 10 to 20 years. One change might make the options that are more environmentally friendly, less economically wise, and less profitable in the near-term more desirable. This would be the initiation of a carbon tax or some other "price" on carbon. One version is cap and trade, which "refers to an environmental policy tool whereby 'caps' or limits are set on the amount of a pollutant that can be emitted" (Stram, 2014). Governments create a limit at which organization and companies may be granted permits or over which they sell permits to allow others to discharge more pollutants (Stram, 2014). "The level of emissions dictated by the cap is almost always lower than existing emissions and is reduced over time" (Stram, 2014). Using cap and trade broadly has basically failed so far, including during climate talks in Kyoto and Rio (Stram, 2014). The method has been used for more localized air pollutants in the U.S., but Stram argued it is not as good for combatting climate change as a carbon tax (Stram, 2014).

A carbon tax is "a fee imposed on the burning of carbon-based fuels" (Carbon Tax Center, 2017). It can be used as a disincentive for fossil fuels, making clean, renewable energy and more stringent energy efficiency look more desirable to both producers and consumers (Carbon Tax Center, 2017). The carbon tax is added upstream during fossil fuel extraction or importing and can be paid the way other taxes are (Carbon Tax Center, 2017).

More than 40 countries and more than 20 provinces, states, cities, or other types of subnational regions have implemented carbon tax or cap and trade so far (Eberhard, 2017). Those with a carbon tax include Denmark, Norway, Portugal, British Columbia and Alberta (Canada), and Chile (Eberhard, 2017). Those with a cap-and-trade program include South Korea, California, Mexico, and China (Eberhard, 2017). These total 13 percent of global GHG emissions (Eberhard, 2017). One study claimed "a price of $75 per ton in developed countries and $35 per ton elsewhere could cut emissions as much as 5.6 metric gigatons, or about a fifth of the way to bridging the emissions gap between where we are now and where we need to be to keep warming in check" (Nunez, n.d.). Currently, existing prices are between $2 and $168 per emitted metric ton (Nunez, n.d.).

Those arguing for a carbon tax say it works, but not always: "In Denmark, which has had a carbon tax since 1992, emissions per person went down 15 percent between 1990 and 2005," and Sweden's emissions fell too, but Norway saw emissions rise after its tax began in the 1990s (Nunez, n.d.). To make it more equitable and less costly for consumers, money can be returned "via tax cuts or rebates elsewhere….A report published in 2014 found that U.S. public support for a carbon price was only 38 percent if the money went toward reducing the federal deficit. But if it went toward a rebate check in the mail? Then 56 percent of people like the idea" (Nunez, n.d.). The profits could also be used for expenditures like infrastructure (Yuan et al, 2017). Carbon tax has some unlikely proponents because it is an inexpensive way to reduce emissions:

"Conservatives should embrace a carbon tax (a much less costly means of reducing greenhouse gas emissions) in return for elimination of EPA regulatory authority over greenhouse gas emissions, abolition of green energy subsidies and regulatory mandates, and offsetting tax cuts to provide for revenue neutrality." (Taylor, 2015)

On the other hand, Stram (2014) argued revenue neutral carbon taxes might not be that beneficial for taxpayers who would still have high costs of non-fossil fuel energy. And producers would not be dis-incentivized with a small tax like $2 per ton. Stram believed revenue should go energy research and development for "alternative means of providing energy services at lower cost than today without potential global warming impacts." To avoid an undue impact on the poor, Stram (2014) said, the extra revenue not used for research can be returned to consumers. Dissou and Karnizova (2016) found that while a carbon tax has higher volatility, it has lower welfare costs than cap-and-trade does. Cap and trade and carbon tax have their individual upsides and downsides.

Better national climate change policy has public support. A poll revealed that citizens "feel the Trump Administration should not remove specific regulations to combat climate change" and a different poll targeting Trump voters found "that nearly two-thirds of these voters support regulating or taxing greenhouse gas emissions" (Yuan et al, 2017). The carbon tax concept is supported by "environmentalists, economists, Republicans and even Exxon Mobil Corp" (Kaufman, 2017). A revenue-neutral carbon tax found support in 66 percent of voters and "the average American is willing to pay nearly 15 percent more for energy each year to help support a carbon tax" according to a survey conducted in late 2016 (Kaufman, 2017). In addition, 80 percent of Americans think carbon tax revenues should be used to develop clean energy (Kaufman, 2017).

The IPCC tells of issues with the international carbon tax idea. Firstly, emissions levels will not be guaranteed unless the tax is continuously changed according to responding emissions desired, and it is very difficult to negotiate any agreement internationally (IPCC, 2001). Nations have to feel like they are "better off" in order to voluntarily participate (IPCC, 2001). Some studies, like the one by Fried at al. (2016) of The Board of Governors of the Federal Reserve System are not entirely against a carbon tax, but warn of welfare costs and the fact that the tax might be regressive when the tax first begins. The authors recommend that "when designing climate policies, policymakers must pay careful attention to not only the long-run outcomes, but also the transitional welfare costs and regressivity of the policy" in order to make outcomes good not only for future generations but for people today as well (Fried et al., 2016, p. 1). It can be politically controversial in other ways too, of course, as "President Barack Obama proposed in early 2016 a $10 per barrel fee on oil, which received blistering criticism from Republicans, who called it 'dead on arrival' and a 'horrible idea'" (Nunez, n.d.). If a price on carbon can be worked out the correct way, the impacts would be immense. The Energy Institute study included scenarios for a high carbon dioxide price and a low carbon dioxide price (Rhodes et al., 2016). With a high price, wind is the least expensive electricity in all of the University Lands counties besides Loving (Rhodes et al., 2016, p. 20).

Wind energy and solar energy will likely have a growing role at University Lands in the years to come. Whether or not the growth will be rapid or slow until policies push it further is unclear. UT has the leadership, widespread support, and research capabilities in sustainability to tie research to policy and affect the approach to leasing and management of University Lands. Of course, it is unlikely that UT divests in fossil fuels anytime soon. Perhaps, however the structure to the PUF and the AUF could be adjusted in my lifetime if climate change is seen as a very serious threat by UT System decision-makers. The revenue from University Lands is an important piece of the system making UT Austin affordable and allowing it to keep its position as an esteemed educational and research institution. Looking forward, my research team and I are thinking about questions for further research and are starting a list of campus resources that future researchers at UT could use to take our project into its next phase. We are thinking about what people interested in furthering this research could do, what else needs to be discovered or who is needed to support the ideas in the report. Certainly, researchers will continue to be interested in sustainability, environmental protection, and climate change, and UT has the resources to figure out how the reach environmental ideals in an economically-oriented and practical way.

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